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UNITED STATES DISTRICT COURT

NORTHERN DISTRICT OF CALIFORNIA

SAN JOSE DIVISION

QUANERGY SYSTEMS, INC. Plaintiff and Counterclaim Defendant, v. VELODYNE LIDAR, INC. Defendant and Counterclaim Plaintiff	Case No.: 5:16-cv-05251-EJD **<u>EXPERT DECLARATION OF GARY KAMERMAN REGARDING CLAIM CONSTRUCTION</u>** Judge: Hon. Edward J. Davila

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I, Gary Kamerman, declare as follows.

I. INTRODUCTION AND QUALIFICATIONS

1. I have been retained by counsel for Quanergy Systems Inc. ("Quanergy") as an expert witness to provide an opinion related to construction of the claims in U.S. Patent No. 7,969,558 (the '558 Patent).

2. I am being compensated for my time in this case at a rate of $500 per hour for my review and analysis of materials, and preparation of this declaration. My compensation in this matter is not determined by or contingent on the outcome of this case.

3. I have reviewed the '558 patent, file history, and the First Amended Joint Claim Construction and Prehearing Statement, including Exhibit A. I have also considered systems and techniques for scanning sensors known to me from my experience in the field. I am willing to testify at the hearing set by the Court regarding the declaration if asked to do so.

4. I reserve the right to supplement my opinions, as well as the bases for my opinions, expressed herein in light of additional materials, including evidence that may be provided to me after submission of this declaration.

5. My qualifications for forming the opinions set forth in this declaration are summarized here and explained in more detail in my curriculum vitae, which is attached as part of Exhibit A.

6. I am a consultant in the field of scanning and non-scanning sensor devices and laser remote sensing to include lidar. I have worked in this field for more than 40 years. My experience includes the design of the scanned Cruise Missile Advanced Guidance (CMAG) sensor for the US Air Force (USAF), the invention of the common-path-homodyne laser Doppler Velocimeter (LDV) and the demonstration of this invention as the scanned navigation sensor for the AGM-129A Advanced Cruise Missile for USAF; the design, and analysis of lidar sensors for the tracking and discrimination of ballistic missile re-entry vehicles for the US Army Space and Missile Defense Command (SMDC); the design, analysis and testing of the scanned Airborne Infrared Lidar Testbed (ALIRT) for a US Government agency that employed Avalanche Photo-Diodes (APDs); the design, analysis and testing of the scanned High Altitude Lidar Operational

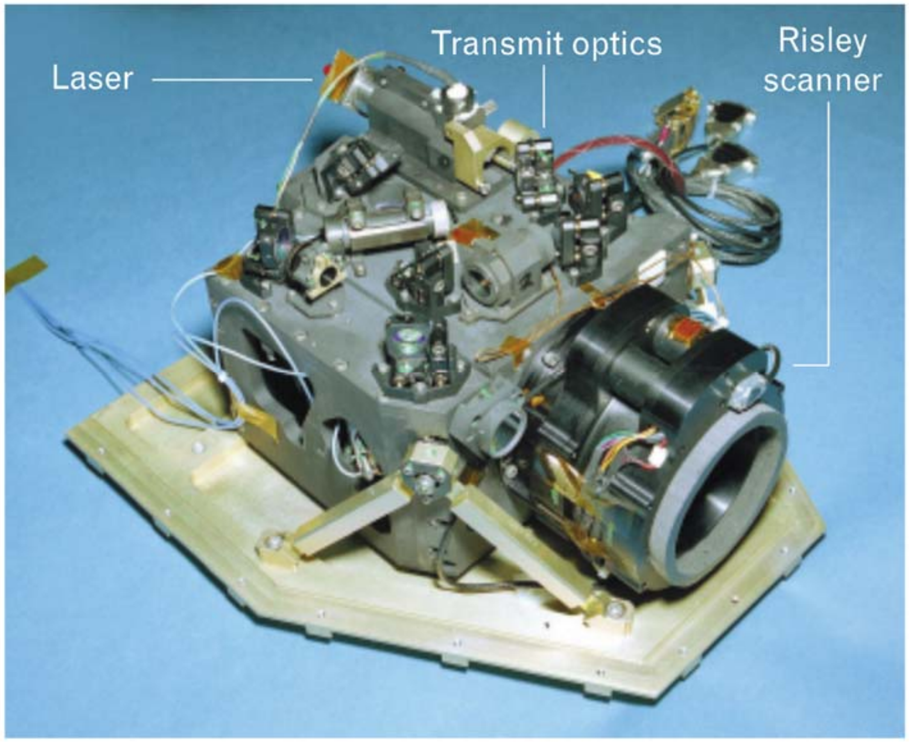
Experiment for the Defense Advanced Research Projects Agency (DARPA) that employed APDs; the test and evaluation of the scanned Jigsaw sensor system for DARPA that employed APDs; the invention and experimental demonstration of optical correlation spectroscopy for SMDC; the experimental evaluation of the scanned Champollion Deep Space 4 landing control sensors for the NASA Jet Propulsion Laboratory that employed APDs; the qualification of the scanned and non-scanned lidar damage inspection sensors used for the Space Shuttle return to flight mission and all subsequent missions for NASA Johnson Space Center; the design, analysis, test and evaluation of lidar sniper fire control sensors for the US Special Operations Command and other efforts classified by the US Government.

7. I am also the author of "Laser Radar" in the *Infrared and Electro-Optical Handbook*, a co-author of the National Academy of Science Report on *Laser Radar: Progress and Opportunities in Active Electro-Optical Sensing* and the editor of more than 40 volumes including the SPIE Milestone series *Selected Papers on Laser Radar*, *Industrial Applications of Laser Radar*, *Applied Laser Radar Technology*, *Optical Instruments for Weather Forecasting*, and *Military Remote Sensing*. I have chaired over forty international conferences on laser radar and related topics held in North America and Europe and I regularly teach optics and laser radar design for the University of Michigan, the Georgia Institute of Technology, Fortune 500 corporations, National Educational TV, and the United States and foreign governments. I am a Fellow of the International Society for Optical Engineering (SPIE) and a distinguished alumnus of the University of Missouri. I have received commendations for my work from the Joint Special Operations Command, NASA, the National Reconnaissance Office, and the Department of Defense.

8. My prior experience with the operation of scanned sensor, lidar and laser remote sensing hardware and its test, evaluation and calibration is particularly relevant to the current topic. CMAG, the AGM-129A LDV, ALIRT, Jigsaw, HALOE, Champollion and the Shuttle Return to Flight parallax sensor were all scanned systems. CMAG, the AGM-129A and Champollion sensor were intended for autonomous vehicle guidance and control. CMAG and Champollion were specifically intended for obstacle detection and hazard avoidance. ALIRT, Jigsaw, HALOE all used a plurality of laser emitters and a plurality of avalanche photodiodes. Some

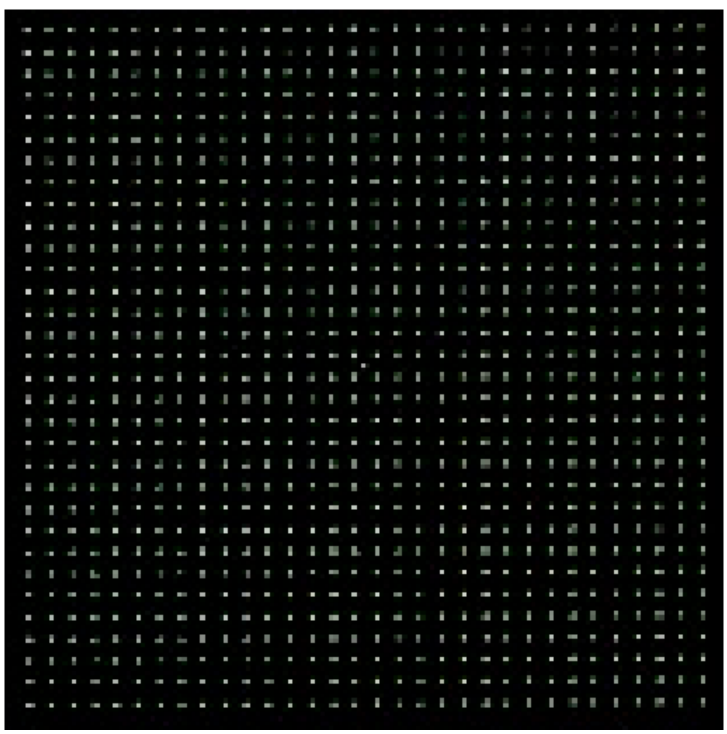
figures showing these projects are shown below.

9. Jigsaw Lidar flight hardware:

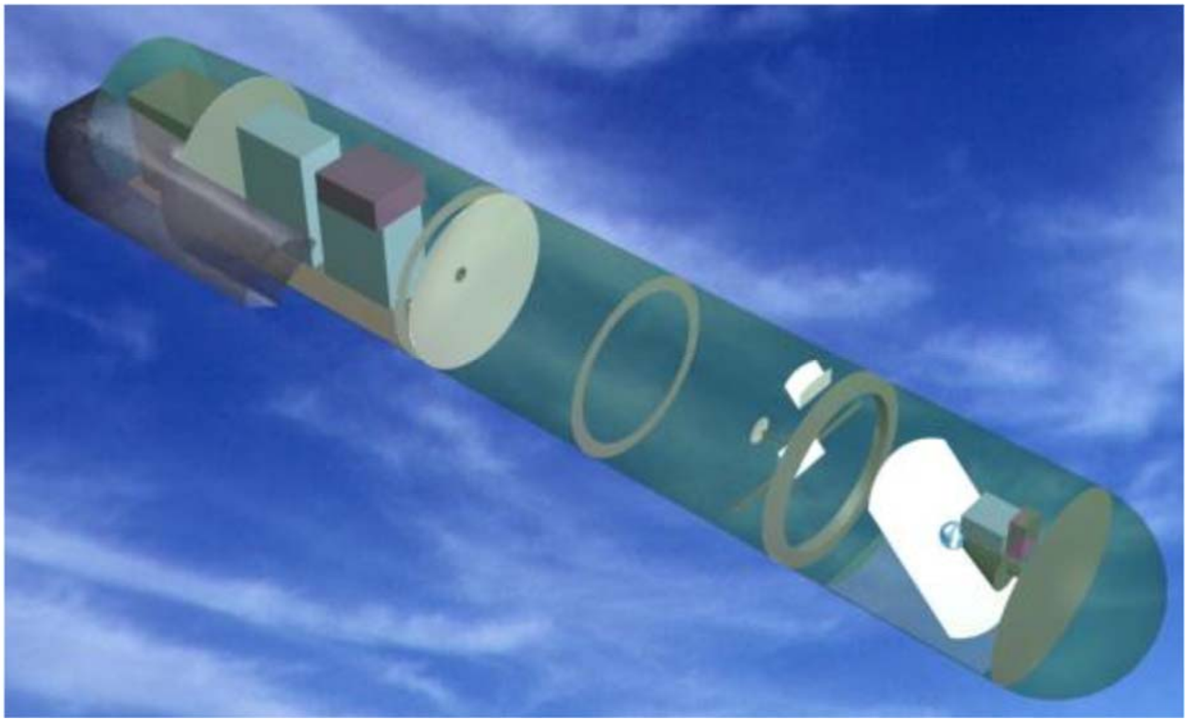


10. Jigsaw CAD Solid Model

11. Jigsaw Laser Emitter Beam Pattern:

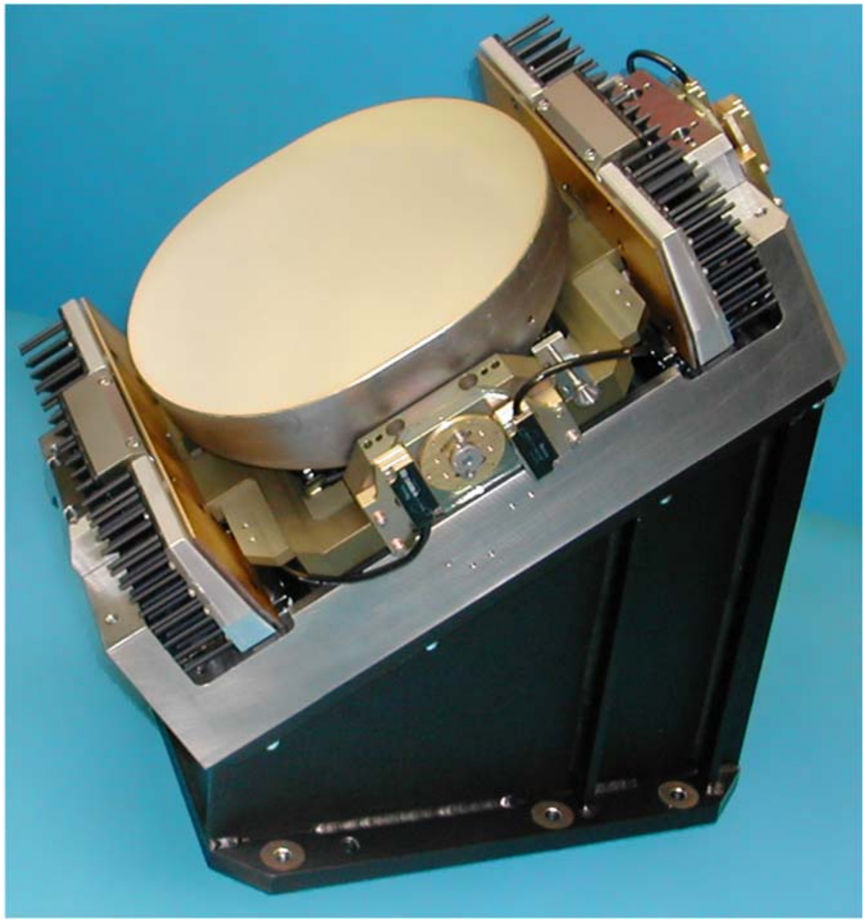


12. Global Hawk Lidar:



13. HALOE:

14. ALIRT Scan Mirror:



II. LEGAL STANDARDS

15. Although I am not an attorney, I have been instructed on the applicable law by counsel for Quanergy and informed by my previous experience as an expert witness in other patent matters as described in my CV.

16. I understand that the words of a claim are generally given their ordinary and customary meaning to a person of ordinary skill in the art (a "POSITA") around the time of the filing of the patent application, and this is the standard that I have applied throughout this declaration. The person of ordinary skill is deemed to read a claim term in the context of the entire patent, including the specification. I also understand that although one is to consider the specification when interpreting the claims of a patent, it is improper to import limitations into the claims from the embodiments described into the specification that are not required by the claims. Similarly, I understand that a construction of a claim term that excludes an embodiment described in

the specification is rarely a proper construction. I also understand that a patent's claim, viewed in light of the specification and prosecution history, must inform those skilled in the art about the scope of the invention with reasonable certainty.

III. LEVEL OF ORDINARY SKILL IN THE ART

17. In determining who would be a person of ordinary skill, I considered at least the following criteria: (a) the type of problems encountered in the art; (b) prior art solutions to those problems; (c) the rapidity with which innovations are made; (d) the sophistication of the technology; and (e) the education level of active workers in the field.

18. In my opinion, a person of ordinary skill in the art ("POSITA") would be a person with at least a Bachelor of Science degree in Electrical Engineering, plus a minimum of four (4) years of experience working in the field of lidar or scanning sensor hardware design with additional training or direct experience in laser safety. A POSITA would also include someone with equivalent experience. My opinion of this matter is formed largely as a result of having hired many individuals who possessed the aforementioned degrees and observing the time required before these individuals were able to work effectively to design, build and test lidar sensors without the risk of injury to themselves or others around them. My opinion on this matter is also based upon my experience assisting in the development of curricular requirements for the laser radar doctoral programs offered by the US Air Force Institute of Technology (AFIT) and the University of Dayton. To my knowledge, these are the only institutions in the United States which offer such degreed programs. My opinion is also assisted by consultations with faculty of institutions outside of the United States which offer comparable degree programs.

IV. A BRIEF BACKGROUND OF SCANNING SENSORS

19. Scanning is a technique commonly applied to sensor systems when the sensor field of view is smaller than region than that which it is desirable for the sensor to collect information. This is often accomplished by mechanical manipulation of the orientation of the sensor itself, as in the human eye, or by manipulation of a mirror or other device that redirects light emitted from or collected by the sensor, as in a periscope. This is in contrast to other organic

sensors, such as the eyes of honeybees or flies, which do not scan and have very large fields of view naturally.

20. In optical sensors, the field of view of a single detector is often quite small in order to achieve narrow angular resolution. However, the narrow resolution also limits the field of view. Without scanning, the field of view is limited to the angular resolution of this single element. Mechanical scanning of single element receiver is generally rather slow as all points in the field of view must be interrogated sequentially, but can, in some cases, provide an effective solution to the dilemma created by the need for narrow angular resolution and wide field of view. An example of this type of sensor is the Riegl Model LMS-Q780 lidar that measures the distance to the ground by measurement of the time of flight of a pulse of light. These data are then used to produce high-resolution topographic maps over broad areas. This particular lidar is scanned by the use of a rotating mirror placed in front of the laser emitter and photodetector. Scanned lidar sensors having a single receiver channel are commonly referred to as "flying-spot scanners" regardless of the specific mechanization used to scan the transmitter and receiver. This class of lidar sensor typically has a frame rate that is limited by size of the frame and the pulse repletion of the laser.

21. In order to increase the field of view that may be accessed in a finite period of time and/or increase the frame rate of the sensor, additional detectors maybe added. To avoid interference between separate receiver channels, primitive multi-element receivers maintained wide angular separation between these channels. Probably the earliest example of this architecture was the active Autonomous Terminal Homing (ATH-A) lidar sensor designed, built and flight tested by the Raytheon Corporation at its Tewksbury, MA facility for the Defense Advance Projects Agency (DARPA) around 1981. This sensor projected two, scanned lidar beams that originated from a single laser device. Scanning was performed by the use of two, single axis, orthogalal, galvanometer driven mirrors. The receiver consisted of two photovoltaic photodiodes. The laser beams were frequency modulated and the distance to each point the target was determined by comparing the currently transmitted frequency to the currently received frequency.

22. In some cases, the field of view may not need to be covered densely as in the ATH-A sensor. The lidar navigation sensor for the AGM-129A Advanced Cruise Missile scanned a single laser emitter and detector about a 120 degree cone using a rotating, transmissive prism. The velocity of the AGM-129A was determined by measurement of the Doppler shift of the light reflected from the ground. Sparse measurement at three positions about the cone were found to be sufficient for navigation

23. Around 2002, a more advanced version of the ATH-A sensor architecture was built by Lockheed Martin in Grand Prairie, TX for the US Air Force. The Polarimetric Imaging Laser Radar (PILAR) Program lidar sensor scanned six (6) laser emitter and avalanche photodetector pairs to densely cover a 30 meter by 30 meter field at a distance of 8 kilometers in order to image targets in 3D. Scanning was accomplished by physically moving a single mirror articulated along two orthogonal axes and distance was determined by round trip time of pulse modulation. The total field of view could be repositioned with respect to the test aircraft by mounting the entire sensor in a gimbaled ball.

24. Sensors such as ATH-A and PILAR could incorporate more channels to further increase the field of view and/or increase the rate at which the field of view is covered. There is a practical limit to the number of discrete detectors that can be packaged in a sensor along with the signal processing and/or signal conditioning electronic required to extract useful information from the signals received. This practical limitation can be partially overcome by the use of arrays of detectors formed on a signal semiconductor chip (a.k.a. focal plane arrays) that are then paired with arrays of integrated circuits (a.k.a. readout integrated circuits or ROICs) intended to extract information from the detector signals and then multiplex that information in order to minimize the number of physical electrical connections needed between the ROIC and the rest of the system. The Jigsaw sensor designed, built and flight tested by MIT/LL for DARPA in 2004 used a diffractive optical element (DOE) to generate more than 1000 laser beams that were paired to more than 1000 avalanche photodiodes formed on a single chip that was bonded onto a ROIC. The sensor used a pair of counter rotating, transmissive prisms (a.k.a., a Risley scanner)

to scan the field of view and collect 3D point clouds of target located under camouflage or vegetation.

25. The alignment of all of the 1000 Jigsaw laser emitters to all of the paired avalanche photodiodes simultaneously was found to be a challenge. Consequently, subsequent scanned lidar sensor employing APD/ROIC receivers (e.g., ALIRT and HALOE) have used a single laser beam to flood illuminate the receiver APD/ROIC. While the mechanical scanning is still somewhat limiting, HALOE has now demonstrated the ability to image in 3D more than 300 square kilometers per hour from a distance of 57 kilometers.

V. PERSON OF ORDINARY SKILL's UNDERSTANDING OF THE CLAIMS

A. "A rotary component configured to rotate the plurality of laser emitters and the plurality of avalanche photodiode detectors at a speed of at least 200 RPM"

26. I have been asked to provide an opinion on the claim limitation "a rotary component configured to rotate the plurality of laser emitters and the plurality of avalanche photodiode detectors at a speed of at least 200 RPM." Claims 1 and 19 of the '558 Patent recite this limitation:

> 1. A lidar-based 3-D point cloud system comprising:
>
> a support structure;
>
> a plurality of laser emitters supported by the support structure;
>
> a plurality of avalanche photodiode detectors supported by the support structure; and
>
> a rotary component configured to rotate the plurality of laser emitters and the plurality of avalanche photodiode detectors at a speed of at least 200 RPM.

('558 Patent, Claim 1.)

> 19. A method of generating a 3-D point cloud comprising:
>
> providing a lidar system having:
>
> a support structure, a plurality of laser emitters supported by the support structure;
>
> a plurality of avalanche photodiode detectors supported by the support structure, and
>
> a rotary component configured to rotate the plurality of laser emitters and the plurality of avalanche photodiode detectors at a speed of at least 200 RPM;
>
> rotating the plurality of laser emitters and the plurality of avalanche photodiode detectors at a speed of at least 200 RPM; and

> emitting light from the plurality of laser emitters.

('558 Patent, Claim 19.)

27. I understand that a claim limitation may be a means-plus-function element, in which the patentee claims a means by the function it performs. I understand that a claim limitation is a means-plus-function element when it recites a function without reciting definite structure that performs the recited function. I understand that the means-plus-function element covers the structure disclosed in the specification, and equivalents, to perform the recited function.

28. A person of skill in the art would understand the limitation "a rotary component configured to rotate the plurality of laser emitters and the plurality of avalanche photodiode detectors at a speed of at least 200 RPM" to be a means-plus-function limitation because it recites a function without reciting definite structure to perform that function. The phrase "to rotate the plurality of laser emitters and the plurality of avalanche photodiode detectors at a speed of at least 200 RPM" is purely functional. The "rotary component" is configured to perform that function, yet the term "rotary component" does not suggest a definite structure to one of skill in the art. For these reasons, this limitation would be understood by one of skill in the art to be a means-plus-function limitation.

1. Function

29. The language of Claim 1 requires that the function of this means-plus-function element must include at least rotating the plurality of laser emitters and the plurality of avalanche photodiode detectors at a speed of at least 200 RPM.

30. The function recited by this means-plus-function element must be construed in light of the other claims in the '558 Patent. I understand that the doctrine of claim differentiation creates a presumption that each claim of a patent has a different scope. Claim 8 is a dependent claim that narrows the scope of claim 1 by adding the phrase "through a full 360 degree rotation":

> 8. The system of claim 1, wherein the rotary component is configured to rotate the support structure through a full 360 degree rotation at the rotation speed of at least 200 RPM.

('558 Patent, Claim 8.) I understand that the function of the means-plus-function element in Claim 1 must be construed to give Claim 8 a different and narrower scope than Claim 1.

31. A person of ordinary skill in the art would understand that because Claim 8 recites rotation through a full 360 degree rotation, the rotation required by Claim 1 would include both rotation through a full 360 degrees (i.e., spinning) and rotation for other than a full 360 degrees. Anything other than a full 360 degree rotation must, of necessity be less than a full 360 degrees of rotation. To interpret the function in Claim 1 as requiring a full 360-degree rotation would remove all independent meaning of Claim 8.

32. It is clear that the '558 Patent anticipates continuous operation. Continuous operation with rotation of less than 360 degrees requires some form of back and forth motion. Scanning devices that rotate back and forth for less than 360 degrees, rather than spin are well known in the industry. For example, the scanning mirror in the ALIRT lidar system rotated back and forth over a physical range of plus or minus 10 degrees at a rate of one hundred times per second. This is an average angular rate of 2000 degrees per second. By comparison, 200 RPM is equivalent to an angular rate of 1200 degrees per second. Thus, given the doctrine of claim differentiation and the successful and common use of sensors which rotate back and forth in the design of scanning sensors, a person of ordinary skilled in the art would understand that the function in claim 1 would include rotating for a full 360 degrees (spinning) or rotating back and forth for less than 360 degrees.

33. Based on this analysis, a person of ordinary skill in the art would understand the function of the means-plus-function limitation "a rotary component configured to rotate the plurality of laser emitters and the plurality of avalanche photodiode detectors at a speed of at least 200 RPM" to be "rotating the plurality of laser emitters and the plurality of avalanche photodiode detectors at a speed of at least 200 RPM for a full 360 degrees or back and forth for less than 360 degree rotation."

2. Structure

34. I understand that the specification of the '558 Patent must disclose the structure corresponding to the function recited in this means-plus-function element. I believe that the

specification of the '558 Patent does not disclose corresponding structure.

35. As explained above, the function of the means-plus-function element is "rotating the plurality of laser emitters and the plurality of avalanche photodiode detectors at a speed of at least 200 RPM for a full 360 degrees or back and forth for less than 360 degree rotation." The specification does not disclose corresponding structure that rotates the plurality of laser emitters and the plurality of avalanche photodiode detectors for less than 360 degrees at an angular rate equivalent to a rotation speed of at least 200 RPM. Rotating the plurality of laser emitters and the plurality of avalanche photodiode detectors back and forth such that they rotate at an angular rate equivalent to a rotation speed of at least 200 RPM would require a structure that permits fast and frequent acceleration and deceleration. There is no such structure disclosed in the '558 Patent.

36. In my experience, I have encountered very fast moving structures in scanning systems that rotate back and forth at high angular rates. Such devices are large, heavy and extremely expensive. The ALIRT mirror structure described above was procured by the United States government at a cost of more than $1,000,000.

37. The '558 Patent does disclose a "spin motor" which is not a particular type of motor. A person of skill in the art would consider the disclosure to teach a person of skill in the art to use a brushed motor.

38. The '558 Patent discloses only a brushed motor such as the corresponding structure. Such a motor can spin at a speed of at least 200 RPM, but cannot go back and forth at an angular rate equivalent to a rotation rate of at least 200 RPM. This is because a device of the dimensions illustrated in all of the embodiments cannot provide rapid acceleration and deceleration, as required to swing back and forth at a rotation rate of at least 200 RPM. The '558 Patent does not disclose a corresponding structure for this means-plus-function element that is capable of rotating back and forth at a speed of at least 200 RPM. Thus the disclosed structure for the claimed function is "a DC motor controller driving a high reliability brushed motor to rotate at a speed of at least 200 RPM for a full 360 degree rotation," and there is no disclosed structure for less than 360 degree rotation.

39. Claim 8 depends from Claim 1. Claim 8 requires that "the rotary component is configured to rotating the support structure through a full 360 degree rotation at the rotation speed of at least 200 RPM." This claim thus requires the following function: rotating the support structure through a full 360 degree rotation at the rotation speed of at least 200 RPM." A structure for performing this function is disclosed in the '558 specification, as explained above. The disclosed structure for the function in Claim 8 is "a DC motor controller driving a high reliability brushed motor," as I further explain in the next section below.

3. Velodyne's Proposed Construction

40. I understand that Velodyne's position is that this claim limitation is a means-plus-function element, and that Velodyne has identified the function as "rotating the plurality of laser emitters and the plurality of avalanche photodiode detectors at a speed of at least 200 RPM," and the corresponding structure as "a motor and equivalents."

41. Although I agree that this claim limitation is a means-plus-function element, I disagree with Velodyne's identified function for the reasons given in my identification of the function above.

42. I also disagree with Velodyne's identification of the corresponding structure. The structure must be limited to the structure specifically disclosed in the specification. The patent discloses "[a] simple DC motor controller driving a high reliability brushed motor controls the rotation of the emitter/detectors." The patentee was aware of brushless motors, as shown by the specification's disclosure of a brushless motor for vehicle control: "Vehicle control is accomplished through the actuation of 2 20 HP brushless motors for brake and steering respectively (see FIGS. 8A, B), controlled by Texas Instruments C2400 DSP chips." The patentee chose, however, not to disclose a brushless motor as corresponding structure for the function of the "rotary component" means-plus-function element.

43. A person of skill in the art would understand the disclosed structure to be a DC motor controller driving a high reliability brushed motor, rather than a generic motor.

B. "Rotary power coupling configured to provide power from an external source to the plurality of laser emitters and the plurality of avalanche photodiode detectors"

44. I have been asked to provide an opinion on the meaning of the claim limitation "a rotary power coupling configured to provide power from an external source to the plurality of laser emitters and the plurality of avalanche photodiode detectors" to a person of ordinary skill in the art. Claim 2 of the '558 Patent recites this limitation:

> 2. The system of claim 1, further comprising a rotary power coupling configured to provide power from an external source to the plurality of laser emitters and the plurality of avalanche photodiode detectors.

45. This limitation contains the phrase "to provide power from an external source to the plurality of laser emitters and the plurality of avalanche photodiode detectors." A person of ordinary skill in the art would thus understand the disclosed function to be, "providing power from an external source to the plurality of laser emitters and the plurality of avalanche photodiode detectors."

46. Claim 2 recites that the rotary power coupling performs that function, yet the term "rotary power coupling" does not suggest a sufficiently definite structure to one of skill in the art. Technical dictionaries support this interpretation. (*See* Exs. B-E.) My experience in lidar systems design also supports my opinion that the term does not connote sufficient structure. Because the claim does not recite sufficiently definite structure, this limitation would be understood by one of skill in the art to be a means-plus-function element.

47. The '558 Patent only discloses one structure corresponding to this means-plus-function element, which is described in connection with Figures 14 and 15:

> As shown in FIGS. 14 and 15, the section 158 includes a magnetic rotor 159 and stator 160. *A rotary coupling 161, such as a three-conductor Mercotac model 305, passes through the center of the section 158 and the rotor 159.* The three conductors facilitated by the rotary coupling are power, signal, and ground. A bearing 162 mounts on the rotary coupling 161. A rotary encoder 163 has one part mounted on the rotary coupling 161 and another part mounted on the base section 158 of the housing 152. The rotary encoder 163, such as a U.S. Digital Model number E6s-1000-750-T-PKG1 provides information regarding to rotary position of the housing 152.

> The magnetic rotor 159 and stator 160 cause rotary motion of the base section 158 and thus the housing 152 about the rotary coupling 161.

(Col. 6, ll. 50-63 (emphasis added).)

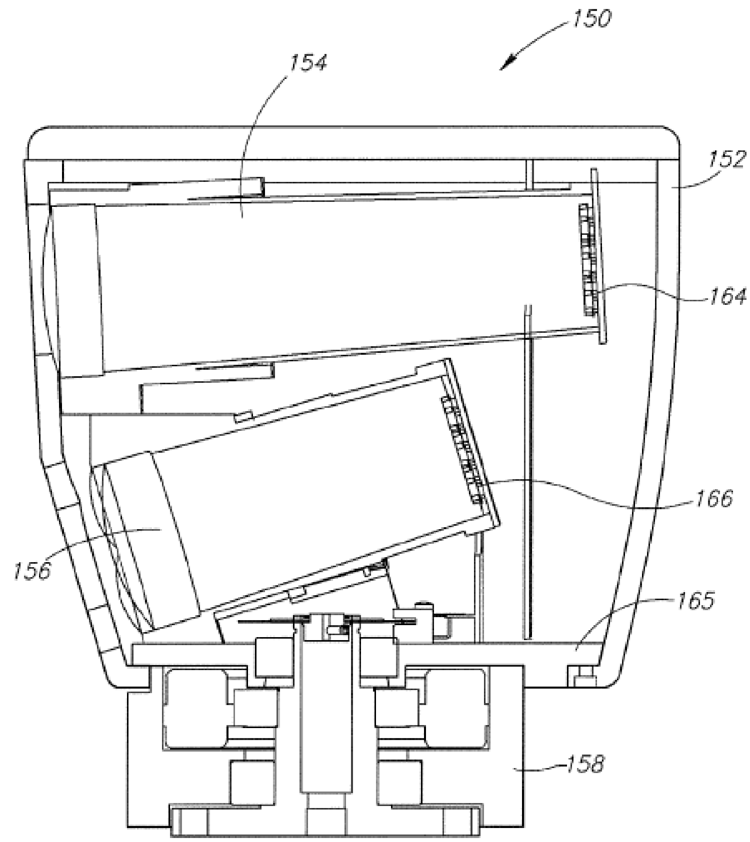


FIG.14

('558 Patent, Figure 14.)

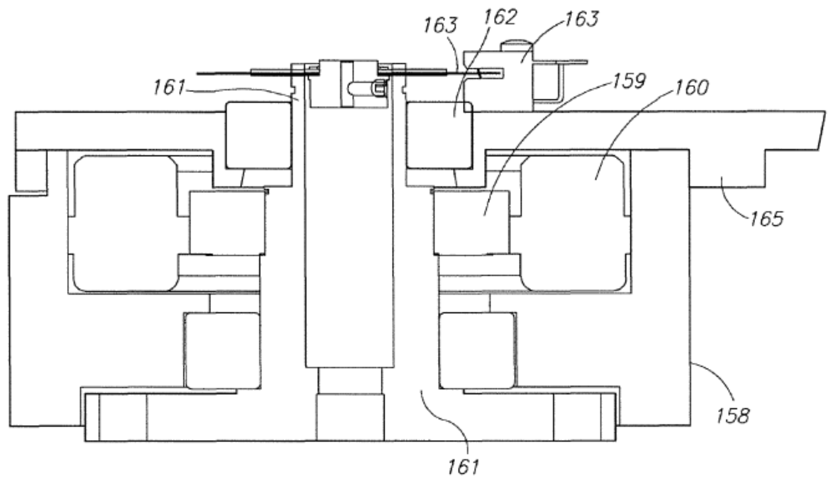


FIG.15

('558 Patent, Figure 15.)

48. The disclosed "Mercotac model 305" is a commercially available rotating electrical conductor that makes use of a liquid metal contact to allow for an electrical connection through a rotating interface. (*See* Ex. F (Mercotac data sheet).)

49. The '558 Patent does not disclose any other structure corresponding to this means-plus-function element. The disclosed structure for performing the function of providing power from an external source to the plurality of laser emitters and the plurality of avalanche photodiode detectors, to a person of ordinary skill in the art, is thus a "three-conductor rotary electrical connector with a liquid metal conductor" for performing the function.

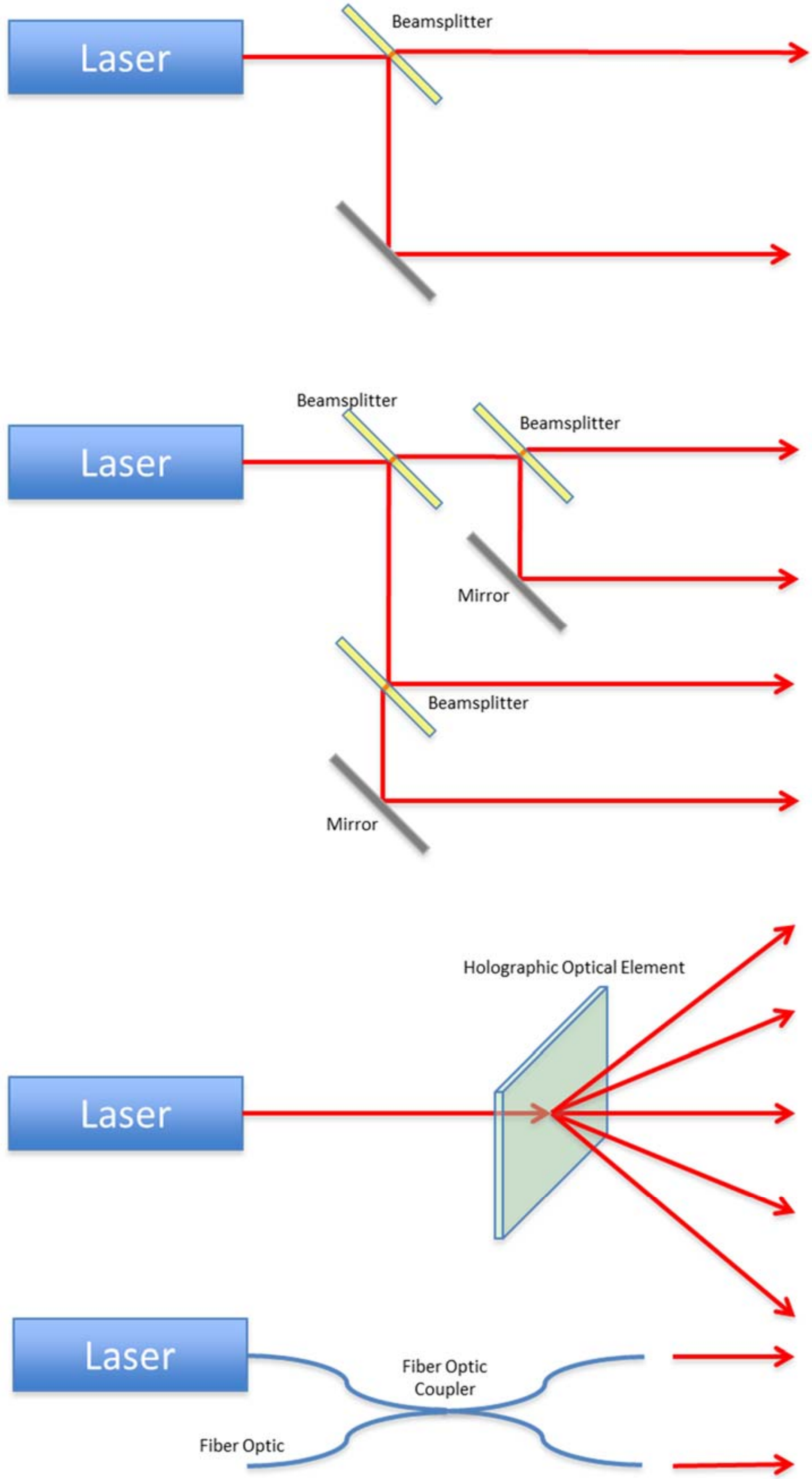
C. "a plurality of laser emitters"

50. Claims 1 and 19 require "a plurality of laser emitters." A plurality means two or more. A person of ordinary skill in scanning devices would understand "a plurality of laser emitters in the claims to mean "two or more light sources that generate laser beams, or a single light source that generates a single laser beam that is sub-divided into two or more smaller beams."

51. I understand that Velodyne's proposed construction is "two or more laser emitters." I agree that the word "plurality" means "two or more". Velodyne's construction, however, fails to explain what a laser emitter would mean in light of the specification and the file history.

52. In laser scanning systems, a laser emitter is often used by persons of ordinary skill in the art to refer a light source that generates optical wavelength electromagnetic radiation (i.e., nominally between 200 nanometers and 25 micrometers) through the process of light amplification by stimulated emission of radiation. It is this process that gives the word laser its meaning and laser light its properties. A person ordinarily skilled in the art would understand that the laser emitter would produce light that has the temporal, spatial and spectral properties typically associated with laser emission. The '558 patent uses the term laser emitter in this sense in several locations. For example, in the background, the specification states, "As is commonly used in devices such as a police speed detector, the basic concept is that of pulsing a laser emitter, which causes a burst of light to be emitted, usually focused through a lens or lens assembly." ('558 Patent, 1:11-15.) The '558 specification discloses one specific laser diode, which is an emitter – the "OSRAM 905nm emitter." ('558 Patent, 5:5.)

53. The '558 patent also uses the term "emitter" to refer to the generation of a laser beam by splitting a single laser-beam into several smaller beams. In particular, the specification states, "[O]ne could also sub-divide a single laser beam into several smaller beams. Each beam would be focused onto its own detector. In any event, *such systems are still considered emitter-detector pairs*." ('558 Patent, 5:1-4.) To a person of ordinary skill, this configuration was well-known and understood to include exemplar configurations such as the four that I have depicted below:


Laser
Beamsplitter
Laser
Beamsplitter
Beamsplitter
Mirror
Beamsplitter
Mirror
Holographic Optical Element
Laser
Laser
Fiber Optic
Coupler
Fiber Optic

54. As seen in my figures above, a single light source generates a single laser beam. That beam may also be divided into several smaller laser beams. The '558 specification states that each of those can be reflected onto its own detector and is still considered an emitter-detector pair. ('558 Patent, 5:1-4.)

55. In light of this disclosure in the specification, a person of ordinary skill in the art would understand that the light source plus beam divider would still be considered a laser emitter as claimed by the invention as long as the division process preserved the basic properties of laser emission.

56. The Summary of the Invention of the '558 specification also confirms that using a single laser beam and splitting it into several smaller beams is a part of the claimed invention. The Summary of the Invention states, "In another aspect of the invention, a single laser beam is divided into several smaller beams, with each smaller beam focused onto its own detector." ('558 Patent, 3:22-24.)

57. The file history of the patents also supports this understanding of "laser emitter" in the claims of the '558 Patent.

58. The examiner rejected all pending claims of the application based, in part, on the Reigl prior art reference. (Ex. H, Sept. 2, 2010 Office Action, at 3-4.) Velodyne then cancelled all of the rejected claims and introduced new claims. (Ex. G, Jan 31, 2011 Office Action Response, at 7.)

59. Velodyne replaced the cancelled claims with claims that recited a "plurality of laser emitters" rather than a "plurality of photon transmitters." (*Id.* at 8 (claim 25, now claim 1; at 10 (claim 43, now claim 19).) A person of skill in the art would understand the "plurality of laser emitters" claim limitation to have constituted a narrowing of the claims to limit the "photon transmitters" to only those which transmit laser beams, in order to overcome the examiner's claim rejection.

60. Moreover, in distinguishing Riegl from the new claim 25 in the file history (now claim 1), Velodyne did not dispute that Riegl discloses a plurality of laser emitters. In at least two locations in the office action response, Velodyne describes Riegl as using a beam splitter,

but does not dispute that this is a plurality of laser emitters, as required by the claims. While Velodyne distinguishes Riegl for having only a single APD and not a plurality of APDs as required, Velodyne does not argue that a beam splitter is not a plurality of laser emitters.

> The Riegl device is a mechanical pan and scan sensor, using ***a beam splitter*** and moving prism to acquire a limited panoramic image. Nothing about the Riegl device even remotely suggests the capability of performing in accordance with the claimed invention; indeed, as explained further below Riegl is woefully deficient. ***Riegl, as with Doemens, does not employ an array of avalanche photodiode detectors (APDs),*** but rather uses an array of photo elements such as CCD or CMOS devices as with Doemens. ***Accordingly, Riegl teaches the use of a single APD to receive a portion of the return signal from the beam splitter***, with the actual imagery being received by the CCD or CMOS elements.

(*Id.* at 14.)

> An additional aspect of claim 25 [now claim 1] is the requirement of a plurality of laser emitters and plurality of avalanche photodiode detectors. As claimed, these pluralities are both rotated at 200 RPM or more. ***With respect to the avalanche photodiode detectors, or APDs, … Riegl teaches that is best to use only one APD*** (reference number 14, also called the receiver; see paragraph 38). ***Riegl splits the beam using a mirror 16 and then directs the split beams toward an array of photo-elements 17 and to the APD receiver 14.*** Thus, not only does Riegl not spin at all or at the rate as claimed, but R***iegl does not employ a plurality of APDs.*** Riegl splits the beam using a mirror 16 and then directs the split beams toward an array of photo-elements 17 and to the APD receiver 14." (*Id.* at 18.)

(*Id.* at 18.)

61. Riegl discloses the kind of device envisioned by the specification of the '558 patent – a device in which a beam and the split beams are directed to an array of photo-elements. But Velodyne does not dispute that this configuration meets the "plurality of laser emitters" claim limitation. Velodyne only distinguishes Riegl because the "photo-elements" are not a plurality of APDs, as required by the claims. This argument is consistent with Velodyne's use of the term emitter in the specification to mean either a single light source emitter, or a light source that is then split using a splitter, as in Riegl, claim 18 in the file history, or the '558 specification, at 5:1-4.

62. Moreover, the dependent claims of the ’558 patent that further specify the laser emitters are consistent with the plurality of emitters including a single light source with a beam splitter. Claims 3-6 each specify details about the emitters that could be met by such a configuration. (’558 Patent, claims 3-6.) For example, claim 3 requires each APD to be paired with a laser emitter. (*Id.*, claim 3.) The multiple pairs is specifically the scenario that the specification describes can be met by a single light source that splits beams that are then paired with multiple detectors. (*Id.*, 5:1-4.)

63. Velodyne’s description of the dependent claims would also inform a person of ordinary skill that Velodyne uses the term “laser emitter” and “emitter” interchangeably, and that each of the dependent claims are broad enough to cover the configuration in which the plurality of emitters may be a single light source with a splitter to create a plurality of light beams. Velodyne states the following:

> While each of the claims should be allowable by depending from claim 25, additional features render the dependent claims separately allowable. Claim 27 requires each of the APDs to be paired with a **laser emitter**. This pairing allows for faster and denser processing than has previously been possible with prior art devices. Claim 28 requires an alignment of **laser emitters** with an angular separation between adjacent **emitters**. This allows for a single array of **emitters** and detectors to be directed outward along a wide area, both near and far, to capture a large field of view. By incorporating this angular separation together with a plurality of APDs and **laser emitters** on a rapidly spinning device, the claimed invention produces a dense point cloud that is suitable for mobile devices. The cited references do not teach this angular separation, particularly with the additional claim requirements, thereby rendering claim 28 allowable. Claim 29 more specifically requires 1/3 degree increments between pairs of **emitters** and APDs, and this feature is not taught or suggested by the art. Similarly, claim 30 requires the alignment of **emitters** and detectors to allow for a line of sight over an area extending between a range of 20 feet and 500 feet from the vehicle. Nothing with the cited references teaches this aspect.

(Ex. G, Jan. 31, 2011 Office Action Resp., at 21 (describing claims 27-30 in the file history, which are now claims 3-7).) The plurality of “emitters” in each of these claims could be either two or more light sources each generating a light beam, or a single light source generating a single light beam, that is divided into multiple beams.

64. A person of ordinary skill would understand the ’558 patent claims that recite a laser emitter to include a system in which a light source/photon transmitter generated a light beam that was then split into multiple beams, the single transmitter plus splitter would still constitute a laser emitter.

D. “the plurality of photon detectors”

65. Claim 3 of the ’558 Patent includes this claim term. The claim recites:

> The system of claim 1, wherein each one of the plurality of laser emitters is paired with a separate one of ***the plurality of photon detectors*** in a fixed position to form a plurality of pairs of laser emitters and avalanche photodiode detectors.

(’558 patent, 8:5-8.)

66. A person of ordinary skill in the art would not understand the scope of this claim to a reasonable certainty because “avalanche photodiode detectors” cited in Claim 1 of the ’558 Patent are understood by a person ordinarily skilled in the art to be a subset of “photon detectors” as required by claim 3. There is no interpretation by which an individual ordinarily skilled in the art can interpret Claim 3 to be narrower than Claim 1 or equivalent to “avalanche photodiode” as not all “photon detectors” are avalanche photodiodes”. Rather, it appears that the patentee has attempted to broaden what is claimed in Claim 1.

67. I understand that Velodyne’s position is that “the plurality of photon detectors” means “avalanche photodiode detectors.” A person of ordinary skill would not understand “photon detectors” to mean “avalanche photodiode detectors” as there many other means to detect photons other than avalanche photodiodes.

68. First, photon detectors mean something broader in their ordinary meaning than avalanche photodiode detectors.

69. Second, the specification itself states that the photon detector can be of different types. For example, the specification indicates that the detecting photo diode may be of the “Avalanche variety, but other types can be used.” (’558 Patent, 5:5-7.)

70. Third, the file history is clear that photon detectors are a broader term than avalanche photodiode detectors. In the claims pending after the preliminary amendment, claim 11

claimed "photon detectors," while claim 20 which depends from claim 11, recited a photodiode. In an office action, the examiner found that the "plurality of photon detectors" claim limitation was in the prior art. (Ex. H, Sept. 2, 2010 Office Action, at 2.) In response, Velodyne cancelled every claim. Those claims all required "photon detectors." (Ex. G, Jan 31, 2011 Office Action Response, at 6-8 (cancelling independent and dependent claims 11-24, all of which required a "plurality of photon detectors").) Velodyne then added new claims 25-49, which all required "a plurality of avalanche photodiode detectors" ("APDs") instead. As previously explained APDs are a specific subset of the many types of photon detectors. Thus, the "photon detectors" term was a broader term that included photodiodes responsive to lasers, as well as other detectors. Thus, a person of ordinary skill would not understand the photon detector in claim 3 to refer only to APDs.

71. Finally, having consistently used "photon detector" to refer to a different claim scope than APDs, a person of ordinary skill would understand claim 3 to be an attempt by the patentee to recapture subject matter surrendered during prosecution. New claim 27 (now claim 3), claims "the plurality of photon detectors." (*Id.* at 8.) This is a broader claim term that was narrowed

72. Finally, I have been asked to opine as to whether a person of ordinary skill would know that the term "plurality of photon detectors" in claim 3 was meant to read "plurality of avalanche photodiode detectors." A person of ordinary skill would not interpret the claim to read something other than the clear language of the claim. Here, Velodyne has used the terms "photon detectors" and "photodiode detector" to refer to a broader scope of detectors. A person of ordinary skill would understand that the term here would have the same meaning that Velodyne had used in other places in its claims and specification. A person of ordinary skill would not rewrite the claim from what it reads, and rather, would not understand the scope of the claim to a reasonable certainty.

73. In addition, a claim term that states "***the*** plurality of photon detectors" refers to something with an antecedent basis, *i.e.*, claimed previously in the same claim or in a claim from which the current claim depends. There is, however, no "plurality of photon detectors" in the

claim 3 or claim 1, from which claim 3 depends. Thus, a person of ordinary skill in the art would not reasonably understand the scope of "the plurality of photon detectors" in claim 3.

74. I understand Velodyne intends to rely on Quanergy's patent publications: 2016/0047901 and 2016/0161600 as evidence that the construction of this term is "avalanche photodiode detectors," because APDs are one type of photodetector. I disagree that this is relevant to construction of this term. While APDs are clearly a type of photon detectors, that does not inform how the term "the plurality of photon detectors" is construed in Claim 3, given its use in the specification and the file history as described above.

E. "a communication component configured to allow transmission of signals generated by the avalanche photodiode detectors to an external component"

75. This claim limitation is a means-plus-function limitation. A "communication component" does not connote structure to a person of ordinary skill in the art.

1. Function

76. This claim term recites "a communication component configured to allow transmission of signals generated by the avalanche photodiode detectors to an external component. .

77. To a person of ordinary skill in the art, an "external component" means a component external to the system. The specification does use the term "external components" to refer to a communication via a rotary coupling or wireless communication. ('558 Patent, 5:67-6:1.) That transmission, however, is not the signal generated by the avalanche photodiode detectors, as explained below. Rather, Claim 9 appears to be directed to a configuration in which the analog signals generated by the APDs are transmitted off of the system for processing. This would be preferable if, for example, there is a large amount of processing required which would make remote processing preferable, or the raw data generated by the APDs is desired for offline processing for uses such as to analyze the granular APD data to determine all of the information that might be gleaned from it. Such needs would be known by persons of ordinary skill in the art, and Claim 9 would be understood to be directed to this type of configuration. Thus, to a person of ordinary skill in the art, the function recited in Claim 9 would be, "allowing transmission of signals generated by the avalanche photodiode detectors to a component external to the system."

2. There Is No Disclosed Structure for This Function.

78. There is no structure disclosed in the ’558 Patent for performing this function.

79. First, a person of ordinary skill would determine what is the “signal generated by the avalanche photodiode detector.” As known to those of skill in the art, an APD, operating with a bias voltage below the breakdown voltage, generates an analog electrical waveform that represents the time-varying intensity of the light incident upon the APD. The specification confirms this well-known fact, referring to the “waveform generated by the detector.” (’558 Patent, 4:32.)

80. Figure 9A shows that the signal generated by the APD is processed using amplifiers and filters, and then converted to digital using an A/D converter, for analysis by a DSP. As depicted in Figure 9A, only the output of the DSP is sent off of the rotating structure through a rotary power coupling. A person of ordinary skill in the art would interpret an amplified and/or filtered analog signal to be a signal generated by the APD. A person ordinarily skilled in the art would not interpret the claim limitation’s requirement for “signal generated by the avalanche photodiode detector” to be referring to a digitized representation of the analog signal nor would a person ordinarily skilled in the art interpret the data generated by processing the digitized representation of the analog signal generated by the APD, and then analyzing those processed signals to be the signal generated by the APD. The difference in these different signals is annotated in Figure 9A below.

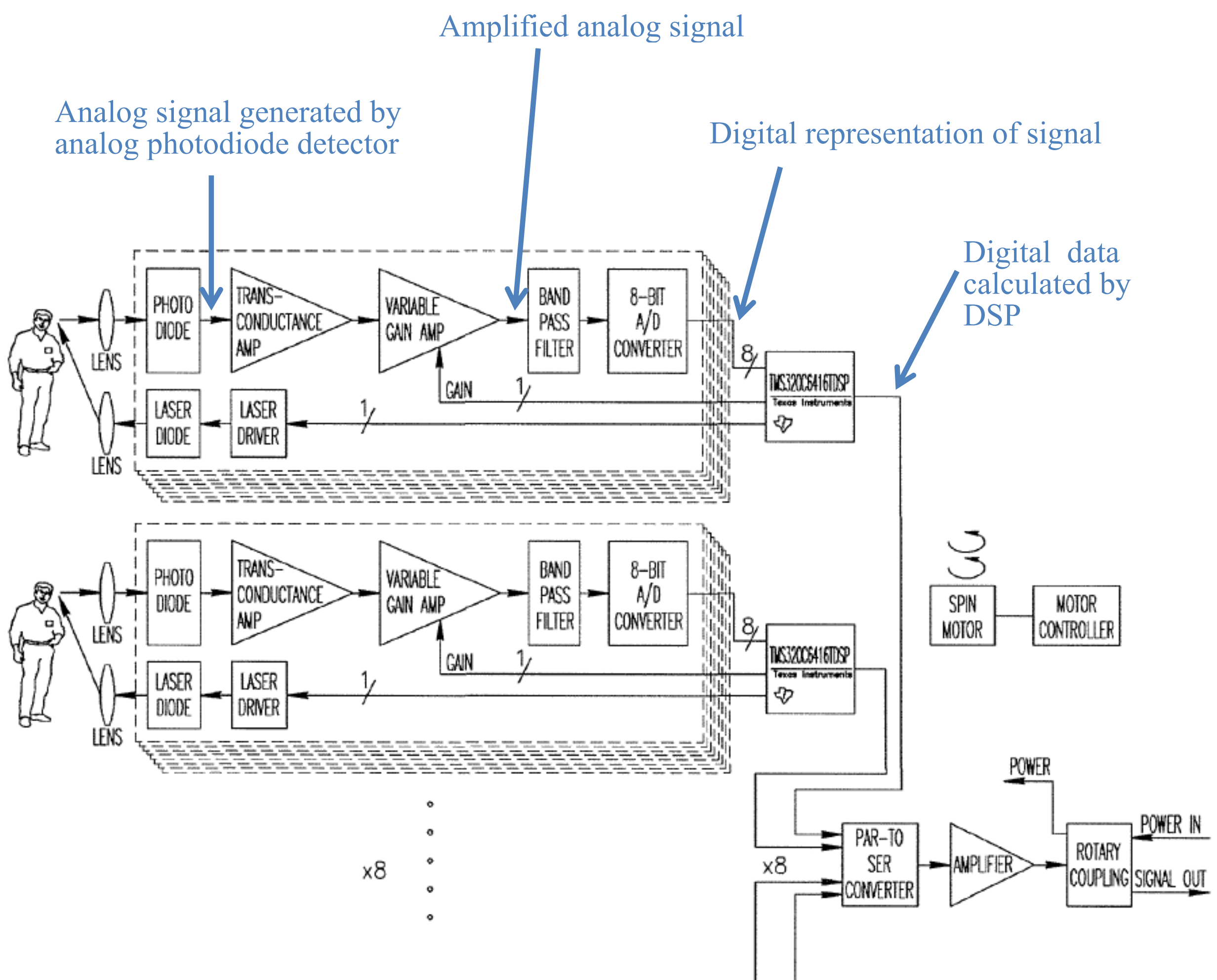


FIG.9A

('558 Patent, Figure 9A (annotated in blue).)

81. The specification also briefly describes the operation of this DSP, stating:

> Each of the emitter/detector pairs are controlled by one or more DSPs, which determines when they will fire, determines the intensity of the firing based on the previous return, records the time-of-flight, calculates height data based time-of-flight and angular alignment of each pair. Results, including multiple returns if any, are transmitted via Ethernet to the master navigational computer via a rotary coupling.

('558 Patent, 5:11-18.) The time-of-flight data and height data would not be understood by a person of ordinary skill as being "signals generated by the" APDs. Rather, the specification refers to these as "data," not signals output from the APD. The use in the specification is thus consistent with the understanding of persons of skilled in the art that processed and analyzed data output from a processor is not a signal "generated" by the APD. The processor may do all types

of processing to determine the data it is going to output, and it may generate error message or alarms. All this downstream processing is not a signal generated by the APDs.

82. There is thus no disclosure in the specification of any structure that allows the signal generated by the APDs to be transmitted to an external component.

83. I understand that it is Velodyne's position that the disclosed structure for the claimed function is "the structure identified at column 4, lines 34-36 and column 3, lines 25-27 (i.e., an Ethernet output (or similar output)" or "a rotary coupling device or a wireless communication device") and equivalents." The disclosures in the specification regarding these structures do not relate to the signal output from the APDs (an analog signal representative of the amount of received light), but some processed data output from the DSP.

84. For example, the specification's reference to "a rotary coupling device or a wireless communication device" is in the specification at column 3, lines 25-27. These lines, however, do not relate to the output of the APDs. This section of the Specification is entitled Summary of the Invention, and parrots language that was in claims originally submitted to the patent office and later withdrawn. Thus, this section of the specification states:

> An example system includes a base, a housing, a plurality of photon transmitters and photon detectors, … and a communication component that allows transmission of signals generated by the photon detectors to external components. …
>
> In still another aspect of the invention, the communication component comprises at least one of a rotary coupling device or a wireless communication device.

('558 Patent, at 3:2-9 and 3:25-27.) This was the language of the original claims 11 and 14, which claimed "a communication component configured to allow transmission of signals generated by the photon detectors to external components" (claim 11) and "wherein the communication component comprises at least one of a rotary coupling device or a wireless communication device." (Ex. I, July 13, 2007 Preliminary Amendment at 15-16.) These claims were rejected by the Examiner and cancelled by Velodyne. This portion of the specification thus refers to claim language that is no longer in the current claims, and would not inform a person of ordinary skill in the art as to the meaning of the communication component in the issued claims.

85. There is another portion of the specification that relates to wireless communications and a coupling for transmission that remains relevant to the understanding of a person of skill in the art, column 5, line 67 to column 6, line 3. I notice that Velodyne does recognize the relevance of this section by citing it as relevant intrinsic evidence. This portion of the specification teaches that the information that may be transmitted via a rotary coupling device is *data*, not the *signal generated by the APDs*:

> The rotating head unit includes multiple detector and emitter circuits each having its own processor. The ***data*** produced by each circuit is output to external components via a rotary coupling. Other data transmission techniques may be used, such as wireless transmission via any of a number of different wireless protocols.

('558 Patent, 5:67-6:3.)

F. "the processor being configured to cause the laser emitters to emit pulses of a reduced power level when at least one of the avalanche photodiode detectors detects a return signal above a threshold level"

86. I have been asked to provide an opinion as to the meaning of "processor" to a person of ordinary skill in the art. This claim term is included in claims 16 and 23 of the '558 patent. Claim 16 states:

> The system of claim 1, further comprising a processor in signal communication with the plurality of avalanche photodiode detectors and the plurality of laser emitters, the processor being configured to cause the laser emitters to emit pulses of a reduced power level when at least one of the avalanche photodiode detectors detects a return signal above a threshold level.

('558 Patent, claim 16.)

87. Regarding reductions of power levels, the specification states the following:

> Through the use of digital signal processor (DSP) control, a dynamic power feature allows the system to increase the intensity of the laser emitters if a clear terrain reflection is not obtained by photo detectors (whether due to reflective surface, weather, or other reasons), and to *reduce power to the laser emitters for safety reasons if a strong reflection signal is detected by photo detectors*.

('558 Patent, 4:20-26.) The reference to safety in the specification would likely cause a person of ordinary skill in the art in designing the hardware of a scanning sensor system would look to recognize that the laser emitters disclosed in the '558 Patent may have safety concerns.

1. Brief Background on Laser Safety

88. By the time of the filing of the '558 Patent, there were many possible standards for laser safety. One such standard was published by the American National Standard Institute ("ANSI") and is entitled the "American National Standard for Safe Use of Lasers." (Ex. J.) This version of this standard in effect at the time of the filing of the '558 Patent is known as ANSI-Z136.1-2000. Another standard was established by the Food and Drug Administration, and is described in 21 C.F.R. § 1040.10.

89. Any laser device operating in the United States must satisfy required laser safety standards.

90. Laser safety is evaluated and certified for devices by a Laser Safety Officer ("LSO"). (*See* Ex. J, ANSI Standard, at 1.) A person of ordinary skill in the art in designing scanning systems or in applying the output of laser scanning systems would have a working knowledge of laser safety, but would likely rely on an LSO for final certification. Even if the designer maintains the credentials of an LSO, certification of one's own work certainly carries with it the appearance of a conflict of interest. While I am not an LSO, I have worked closely with several LSOs over the course of my 40 years' experience designing scanning systems, such that I do have a working knowledge of the ANSI standard and other safety standards. My experience working with laser safety and laser safety standards includes: the analytical evaluation of the ocular hazards posed by NATO-standard laser designators, the experimental evaluation of vulnerability of various satellite systems by high power laser weapon systems for the US Air Force under the Satellite Materials Hardening (SMATH) program, the design, analysis and implementation of laser safety barriers devices for my laboratory in order to safely conduct SMATH tests, the analysis of aided and unaided ocular hazards to personnel on the ground from ALIRT flight tests, the analysis of aided and unaided ocular hazards to personnel on the ground from HALOE flight tests, the analysis of aided and unaided ocular hazards to personnel on the

ground from Jigsaw flight tests, the analysis of aided and unaided ocular hazards to personnel on the ground from SPi3D flight tests, the analysis of aided and unaided ocular hazards to personnel on the ground from the operation of several commercial laser mapping sensor systems, and the analysis of aided and unaided ocular hazards to personnel on the ground from certain classified tests.

91. Since, LSO approval is required for final checking and legal certification, it is necessary for me to have a comprehensive understanding of the criteria that the certification authority will base his judgment on in order to specify the design and expect it to be approved.

92. The first step in using a safety standard is determining the appropriate class of the laser or laser system. (*See* Ex. J, ANSI Standard, at 1.) There are differing requirements for different Classes of devices. The ANSI standard introduces these differences as follows:

> The basis of the hazard classification scheme in Section 3 of this standard is the ability of the primary laser beam or reflected primary laser beam to cause biological damage to the eye or skin during use. For example, a Class 1 laser system is considered to be incapable of producing damaging radiation levels during operation and is, therefore, exempt from any control measures or other forms of surveillance. A Class 2 laser system emits in the visible portion of the spectrum (0.4 to 0. 7 μm) and eye protection is normally afforded by the aversion response, including the blink reflex. Class 3 laser systems (medium-power) are divided into two subclasses, 3a and 3b. A Class 3 laser system may be hazardous under direct and specular reflection viewing conditions, but the diffuse reflection is usually not a hazard. A Class 3 laser system is normally not a fire hazard. A Class 4 laser system (high-power) is a hazard to the eye or skin from the direct beam, and sometimes from a diffuse reflection, and can also be a fire hazard. A Class 4 laser system may also produce laser generated air contaminants (LGAC) and hazardous plasma radiation (see Section 7).

(*Id.*)

93. Safety standards for lasers have been required on all systems on which I have worked for at least 40 years. As noted above, lasers operated at different wavelengths and in different environments must determine which class is appropriate for that environment and design appropriate safety mechanisms or procedures into that device. The Class and many other factors can then be used to determine the Maximum Permissible Exposure ("MPE").

94. Regarding safety, Velodyne included two statements in the prosecution history when amending its claims on January 31, 2011. Referring in particular to an embodiment of the claimed invention that would operate in an autonomous navigation context, Velodyne stated:

- "… such an [autonomous vehicle navigation] system must provide … Class one eye safety …" (Ex. G, Jan. 31, 2011 Response, at 15.)
- "… neither system [cited by the Examiner] is concerned with … the power levels and safety issues unique to such a system." (*Id.*)

Neither of these statements limit the scope of any claim term related to safety or the type of safety the claims are referring to.

95. The first statement says that in an autonomous navigation system context, the system must provide Class 1 safety. First, I disagree. The system must be eye safe. Class 2 and Class 3 laser devices may be made eye safe, if the appropriate procedures and mechanisms are put in place. Furthermore, the patentee recognized this fact as is evidenced by the inclusion of "control measures" (i.e., "reduce power to the laser emitters for safety reasons") in the '558 Patent. Control measures are not applicable for Class 1 laser devices. Nonetheless, the statement is limited to use of the invention in the autonomous vehicle navigation context, but none of the claims limits the invention to that context, as further described with respect to the preamble terms below.

96. Regarding the second statement in the file history, a person of ordinary skill in the art would not understand this statement as making the claimed safety features more definite. The patentee states that there are "power levels and safety issues unique to such as system." If there are such "power levels or safety issues unique" to the claimed context, the patentee failed to provide any information as to how those issues are unique that would direct a person of ordinary skill as to how to apply the published industry safety standards.

97. Laser safety standards, like the ANSI standard, are like a cookbook. It requires knowledge as to what is being cooked (the class of the device, where it will be used, who will be using it), as well as what are the parameters of what we should cook (how much, what do we

have to cook with, what are the preferences of the users). Someone of ordinary skill in the art would not understand Velodyne to have claimed the entire field of laser safety, which has been known for many years. If there is something specific about how the ’558 patent says that laser safety standards should be applied, it fails to provide any such description or teaching to a person of ordinary skill.

98. Instead, the devices claimed in the ’558 Patent could be used in any Class of device. The claims, specification, and file history, do not limit its use to any particular class. Within any particular class, the specification does not disclose various factors necessary to determine the requirements for laser safety including: the wavelength (*i.e.*, color) of the laser, the duration of the pulses, the transmitted power of the laser, the enclosure in which the laser will operate, whether the laser pulses once or repeatedly. In particular, the patentee has not indicated the manner in which the invention poses a unique safety hazard. Based on these factors, a person of ordinary skill in lasers would try to determine what the maximum permissible exposure is for that wavelength, that pulse length, that pulse repetition frequency, that laser emitter beam divergence, the minimum accessible distance, the largest feasible optical aiding device (e.g., binoculars) and maximum possible exposure time (to include cumulative exposures resulting from subsequent scans). However, none of these factors are unique to the disclosed invention and are well covered in the ANSI standard. Thus, a person of ordinary skill in applying laser standard safety to devices covered by the ’558 Patent is left with the knowledge that the patentee believes that the standard application of the 184 page ANSI standard is inadequate as there are undisclosed issue that are “unique to such a system, with no detail as to which sections or criteria to apply to mitigate these unique safety issues. I discuss this uncertainty in the scope of the claims further in the following sections.

2. “cause the laser emitters to emit pulses of a reduced power level when at least one of the avalanche photodiode detectors detects a return signal above a threshold level”.

99. This term, viewed in light of the specification and prosecution history, does not inform a person of ordinary skilled in the art about the scope of the invention with reasonable certainty.

100. For this claim term, one ordinarily skilled in the art would understand "a threshold level" to means a singular voltage level used to compare the detected signal intensity or corresponding voltage generated by the APD in response to that singular signal intensity.

101. This claim term does not inform a person of ordinary skill with reasonable certainty as to what "threshold level" should be determined. The naturally received signal can be reasonably expected to vary in amplitude by a factor of one million or more. How to establish a singular threshold appropriate for all environmental conditions, material reflectivity, object distances and circumstances would not be understood to someone ordinarily skilled in the art.

102. Moreover, a "return signal" can be measured in multiple ways. The threshold could be measured using the intensity of the received signal itself, which could then be compared with the then-applicable threshold. The return signal could also be measured by measuring the width of the received signal, and possibly estimating the intensity based on that width. (*See, e.g.*, U.S. 2014;0211194, Para. 6.) The threshold could also be measured using the intensity and the pulse width in order to determine the total energy received. Using one measurement, the return signal might exceed the threshold, while using another measurement, it does not. A person of ordinary skill in the art would not know with reasonable certainty the scope of the claim, because different measurements of the return signal would lead to the same device being within and outside the scope of the claim.

103. In addition, the claim does not inform one of ordinary skill what is required in the claimed "emit pulses of a reduced power level." The claim does not state how many pulses should have a reduced power level, to what level the pulses should be reduced and whether by reduced power level, it includes shutting off the laser.

104. In addition, the language or claim 16 fails to inform one of skill in the art as to the scope of the invention, as described here. As described by the claim, if any one of the detectors receive a signal above an unspecified threshold, then the power to be transmitted by the lasers are to be reduced by an unspecified amount. Since safety is the basis for the described function, one ordinarily skilled in the art will presume that the signal that exceeded this threshold was the result of a bright retro-reflection generated by a human eye. This type of retro-reflection is

commonly known within the art as "optical augmentation" and is the cause of the common "red eye" effect seen in flash photography.

105. The described procedure could provide increased eye safety under the circumstances where the laser emission does not exceed the MPE for a single pulse but, because of the rotation rate and the divergence of the beam, the eye could be illuminated by several successive pulses and these pulses and, if not diminished in amplitude, exposure to these successive pulses could exceed the multi-pulse MPE. In such systems, the threshold level typically varies with the range according to some defined analytical equation. For example, a return signal produced by the retro reflection from a human eye and at a given range and a return signal of exactly the same amplitude from a human eye that was at twice that range would indicate that they eye at a greater distance was illuminated by a laser having four time (4X) that of the closer eye. Thus, one ordinarily skilled in the art would anticipate that the threshold should be adapted for range.

106. However, Claim 16 cites "***a*** threshold level" [bold italics added for emphasis]. An adaptable threshold level is not a single threshold level but a continuously adjusting threshold. It is unclear if an adaptable threshold would infringe upon the ’558 Patent.

107. Claim 16 also does not explain how much the power should be reduced, how long the power is to be reduced or what should happen if a subsequent return signal also exceeds the threshold. The claim seems to indicate that the signals from all detectors are to analyzed as a group that is limited to the signals produced by a single firing of the laser emitters. If the signals from all detectors from two successive firings of the laser emitters were to be analyzed as a group, would this infringe the claim? If only the laser emitter corresponding to the detector that detected the received signal that exceeded the threshold were to have its power reduced, would that infringe? These questions are not answered or addressed by the ’558 Patent.

3. “Processor” Does Not Connote Sufficiently Definite Structure.

108. I have also been asked to opine as to whether the “processor” in claim 16 connotes sufficiently definite structure to a person of ordinary skill in the art. In my opinion, it does not.

109. The only description of the processor's structure within the claim is that it is "in signal communication with the plurality of avalanche photodiode detectors and the plurality of laser emitters." The claim goes on to state that the processor must perform the function of "causing the laser emitters to emit pulses of a reduced power level when at least one of the avalanche photodiode detectors detects a return signal above a threshold level."

110. A person of ordinary skill in the art would not recognize the "processor" as a name for sufficiently definite structure given these limitations.

111. As an initial matter, the functionality and connectivity of the claimed processor are not those typically found in a commercially available off-the-shelf general purpose processor. Thus, a person of ordinary skill in the art would understand the claimed processor to require some structure in addition to an off-the-shelf general-purpose processor (such as specialized programming, external memory or other supporting components). The claimed "processor" does not provide that structure. As used within Claim 16, "processor" is just a generic description for an undefined combination of software or hardware that performs the function of controlling the emissions of the laser emitters.

112. The limitation that the processor must be in "signal connectivity" with the emitters and APDs does not provide structure to the processor. This merely provides that there must be some connectivity from the processor to other components of the system. This claim language would not inform a person of skill in the art as to the structure of the "processor" with sufficient definiteness. It also does not provide structure the those elements necessary to provide signal connectivity between the emitters, APDs and the processor

113. At the time of the filing of the '558 Patent, there were a wide variety of electronic components that could meet the requirements of being in "signal communication with the plurality of avalanche photodiode detectors and the plurality of laser emitters" and also "cause the laser emitters to emit pulses of a reduced power level when at least one of the avalanche photodiode detectors detects a return signal above a threshold level." A processor could be, for example, a general purpose computer with specialized programming, a digital signal processor (DSP) with specialized programming, a Field Programmable Gate Array (FPGA), a set of discrete ana-

log electronic components that perform the claimed functionality or a set of hybrid set of analog and digital discrete electronic components that perform the claimed functionality.

114. For example, in 1978, I built a processing system that remotely controlled the movement and alignment of optical components that were physically inaccessible within an evacuated chamber using discrete components. That is, it used discrete digital components based upon transistor-transistor logic (TTL) to sense the position of certain components, compute the change in position needed to re-position those components into proper alignment and then generated the commands to various motors and other electromechanical devices required to effect the computed re-positioning. This set of discrete TTL components may be properly described as a processor.

115. Dictionary definitions support my opinion that a processor is not a name for sufficiently definite structure for "causing" changes to the emissions of laser detectors. (*See*, Exs. B, C, E, J, K, L.)

116. I understand that Velodyne intends to rely on U.S. patent publication 2014/0211194 as evidence regarding construction of the term "processor". This publication supports my position that the claimed "processor" is not sufficiently definite structure. For example, at paragraph 14, the publication states that the electronic control circuitry controlling that invention "can be implemented with discrete integrated circuits (ICs), in the form of FPGA logic, as part of an application-specific integrated circuit (ASIC), or integrated into the pixels of a detector array (e.g., Single Photon Avalanche Diode [SPAD] array)." Each of these require widely different knowledge and information to implement. Merely claiming a "processor" does not connote sufficiently definite structure.

4. As A Means-Plus-Function Term, the Term Does Not Disclose an Algorithm.

117. I understand that when construed as a means-plus-function term, the claimed functional structure is limited to the structures disclosed in the specification.

118. Here, the claimed function is "causing the laser emitters to emit pulses of a reduced power level when at least one of the avalanche photodiode detectors detects a return sig-

nal above a threshold level." As I described previously, the scope of this claim language is not reasonably certain.

119. In addition, there is no disclosed structure (including hardware and an algorithm) for this function in the specification.

120. The specification states that control of the laser emitters is performed by a digital signal processor:

> Through the use of ***digital signal processor (DSP)*** control, a dynamic power feature allows the system to increase the intensity of the laser emitters if a clear terrain reflection is not obtained by photo detectors (whether due to reflective surface, weather, or other reasons), and to reduce power to the laser emitters for safety reasons if a strong reflection signal is detected by photo detectors.

('558 Patent, 4:20-26.)

121. A digital signal processor is a type of processor typically used to perform signal processing applications optimally. The description of the use of a digital signal processor here indicates that the hardware for performing the claimed "function" is a digital signal processor.

122. A digital signal processor by itself could not carry out the claimed function, but requires specialized software running a specific algorithm to do so. The specification for the '558 Patent does not disclose an algorithm for "causing the laser emitters to emit pulses of a reduced power level when at least one of the avalanche photodiode detectors detects a return signal above a threshold level." An arbitrary reduction in power cannot be relied upon to implement safe operation should the detection of a returned signal above a threshold is to indicate an unsafe condition should operation to continue unabated. The reduction in power must itself be purposeful in order to implement the function of safety. There is simply no algorithm disclosed for performing the claimed function.

G. "the processor being configured to prevent the laser emitters from firing when the rotary component is not rotating"/ "the processor being configured to prevent the laser emitters from firing when the rotary component is rotating below a threshold level"

123. I have been asked to provide an opinion as to the meaning of this term to a person of ordinary skill in the art. These related claim terms are included in claims 17 (with a method

claim at 24) and 18 of the '558 patent. The system claims state:

> The system of claim 1, further comprising a processor in signal communication with the plurality of laser emitters, the processor being configured to prevent the laser emitters from firing when the rotary component is not rotating.

('558 Patent, claim 17.)

> The system of claim 1, further comprising a processor in signal communication with the plurality of laser emitters, the processor being configured to prevent the laser emitters from firing when the rotary component is rotating below a threshold level.

('558 Patent, claim 18.)

124. Claims 17 and 18 both require that the claimed processor is (1) in signal communication with the plurality of laser emitters; and (2) configured to prevent the laser emitters from firing. While Claim 17 requires the processor to prevent the laser emitters from firing "when the rotary component is not rotating," Claim 18 requires this "when the rotary component is rotating below a threshold."

1. "prevent the laser emitters from firing when the rotary component is rotating below a threshold level" (claim 18) / "prevent the laser emitters from firing when the rotary component is not rotating" (claim 17).

125. As I have described previously with respect to the "rotary component" claim limitation, the "rotary component" itself does not have a reasonably certain scope. I incorporate that analysis here.

126. In addition, to a person of ordinary skill the specification and file history provide no information as to how to determine the critical threshold level at which to stop the firing of the lasers, or how long to stop the firing of the laser emitters.

127. In addition, as with the Claim 16 function, the claim term in Claim 18 does not inform a person of ordinary skill with reasonable certainty as to what "threshold level" should be determined. The naturally received signal can be reasonably expected to vary in amplitude by a factor of one million or more. The establishment of a singular threshold appropriate for all environmental conditions, material reflectivity, object distances and circumstances is not certain to someone ordinarily skilled in the art.

128. However, Claim 18 cites "***a*** threshold level" [bold italics added for emphasis]. An adaptable threshold level is not a single threshold level but a continuously adjusting threshold. It would not be understood to a person of skill in the art whether an adaptable threshold would infringe upon the ’558 Patent.

129. There is no description in the specification of why a user would prevent laser emitters from firing based on these criteria. The prosecution history, however, includes the following explanation:

> Claim 40 [now claim 17] provides a processor that prevents the lasers from firing when the rotary component is not rotating, while claim 41 [now claim 18] prevents the emitters from firing when the rotation speed is below a threshold level. These aspects are not taught by the cited references, and are not obvious in view of their teachings. The prior art systems did not spin at the rate as with the claimed invention, and therefore had no need to consider these aspects. But in a device having a high spin rate and with high power lasers and APDs, it is important not to fire the lasers when they are stationary because it may result in eye damage or cause other problems.

(Ex. G, Jan. 31, 2011 Office Action Response, at 22.) Given this description, a person of ordinary skill in scanning system design would understand these claim limitations to also apply to laser safety, as with Claim 16.

130. As an initial matter, I disagree with the premise of the response given by Velodyne to the patent office. Velodyne claims that systems that “did not spin at the rate as with the claim invention … had no need to consider these aspects.” This is not correct. When a device spins more slowly, it is *more* important to consider safety considerations, as it is more likely that the device will point at a particular location long enough that multiple pulses will illuminate that location and cause damage that would not have occurred if illuminated by a single pulse. The fact that the ’558 Patent concerns itself with laser safety when it is spinning slowly is further confirmation that previous art, operating at reduced rates, would have given these aspects consideration as well. In addition, it is always important for lasers to reduce the emitted power or stop transmission when they exceed certain limits, regardless of the application. How the device performs this varies widely, depending on the particular device being built.

131. The ANSI standard requires the following for scanning laser devices:

> 4.5.1.5 Scanning Devices. Scanning devices, including rotating mirrored balls, shall incorporate a means to prevent laser emission if scan failure or other failure resulting in a change in either scan velocity or amplitude would result in failure to fulfill the criteria given in 4.5.1.3 and 4.5.1.4.

(Ex. J, ANSI Standard, at Section 4.5.1.5.) That is, the standard requires that if the speed of scanning ("scan velocity") or the amplitude of the scanning result in the system exceeding specifically prescribed optical radiation limits, then the system must stop transmitting ("prevent laser emission"). Still, the "criteria" and all of the ways in which this could be met vary widely (justifying standards of hundreds of pages). For example, it may only be necessary to prevent firing of the emitters for every nth pulse in order to still maintain the necessary laser safety standard, even when the laser is rotating at a speed below some threshold. It is therefore not reasonably certain whether it is within the scope of the claims to only prevent emitting some of the pulses or if all of the pulses must be stopped in order to be within the scope of the claims.

132. The laser emitters themselves do not provide information sufficient to determine that the rotary component is rotating or rotating below a threshold level.

133. How to determine that the rotary component is not rotating or rotating below a threshold is not identified within Claim 17 or Claim 18. Within the specification, a "rotary encoder … provides information regarding rotary position" and provides the part number of an exemplar of such an encoder. ('558 Patent, 6:56-61.) One ordinarily skilled in the art would anticipate the use of such a device to determine the rotational position. However, the identified part, U.S. Digital Model number E6s-1000-750-T-PKG1, is not a position sensor as described in the specification. ('558 Patent, 6:58-60 (stating that this part provides "rotary position of the housing").) Rather, the specific part number provided in the specification appears to provide information on angular rate but not position. One skilled in the art is unable to determine if the claims require determining whether the rotary component is rotating using an angular rate sensor or an angular position sensor. Depending on which type of sensor is used, the processor will have to use a different algorithm to determine whether the rotary component is rotating and at what

speed. In addition, the encoder described in the specification would be used to determine whether a "housing" is rotating. Claims 17 and 18 require determining whether the "rotary component" is rotating and the speed of rotation. Velodyne's position is that the rotary component is the motor itself. I am not aware of a rotary encoder such as that described in the specification determining the rate at which a motor is spinning. While the motor is spinning at a certain speed, the system may be designed such that the emitters and detectors are spinning at a different rate. Moreover, the claimed structure in Claims 17 and 18 may not have a housing at all. As the claims show, only dependent claim 10 requires a housing and a base, while claim 1 does not. Thus, there is no disclosure of how one would measure the rotation of the rotary component or motor itself.

134. Rather, in some circumstances the claim would be infringed, while in others it would not. Thus, the scope of claims 17 and 18 is not reasonably certain to a person of ordinary skill.

2. As a Means-Plus-Function Term, the Term Does Not Disclose an Algorithm.

135. As I have previously described with respect to the Claim 16 term, the "processor" does not connote sufficiently definite structure. The same reasoning applies to Claims 17 and 18 and I incorporate my previous analysis here.

136. If Claims 17 and 18 are interpreted as means-plus-function claim terms, the claimed functions would be understood as: "preventing the laser emitters from firing when the rotary component is rotating below a threshold level" and "preventing the laser emit-ters from firing when the rotary component is not rotating.

137. As described above, a person of ordinary skill would understand the specification to disclose a digital signal processor performing some proprietary algorithm as the disclosed structure. ('558 Patent, 5:11-12.) The specification does not disclose any algorithm for preventing the emitters from firing when the rotary component is rotating below a certain threshold or not rotating. As explained previously, there are numerous possible algorithms for determining the one or more thresholds that can be used depending on the required standard and the particular

"unique" circumstances of the structure. Some of these would result in infringement, while others would not. In the prosecution history, Velodyne states that unique requirements are needed for its claimed structure, but fails to provide any information regarding how those requirements are calculated or determined.

138. Velodyne's proposed means-plus-function constructions for this term as well as those in claims 16 and 19 appear to state that the language of the claim is itself an algorithm. I disagree. The terms "prevent the laser emitters from firing when the rotary component is rotating below a threshold level" or "prevent the laser emitters from firing when the rotary component is not rotating" (and the terms in claims 16 and 19) are functions that must be implemented using a specific algorithm.

H. "the processor being configured to control the firing of the laser emitters in relation to the rotation of the rotary component, the step of emitting light from the plurality of laser emitters further comprising causing the laser emitters to emit light only when the rotary component is rotating above a threshold level"

139. I have been asked to provide an opinion as to the meaning of this term to a person of ordinary skill in the art. This claim term is included in claim 25 of the '558 patent. The claim states:

> The method of claim 19, wherein the lidar system further comprises a processor in signal communication with the plurality of avalanche photodiode detectors and the plurality of laser emitters, the processor being configured to control the firing of the laser emitters in relation to the rotation of the rotary component, the step of emitting light from the plurality of laser emitters further comprising ***causing the laser emitters to emit light only when the rotary component is rotating above a threshold level***.

('558 Patent, Claim 25.)

140. Like Claim 16, this claim requires that the claimed processor is in "signal communication" with the plurality of laser emitters and APDs. The claimed function then requires the opposite of the term in Claim 18, that the processor is configured to only emit light when the rotary component is *above* a threshold level.

1. "causing the laser emitters to emit light only when the rotary component is rotating above a threshold level."

141. As I have previously described, the "rotary component" term itself does not have a reasonably certain claim scope. I incorporate that analysis here.

142. In addition, the specification and file history do not inform the scope of Claim 25. When adding this and other method claims during prosecution (Claim 25 was then claim 49), Velodyne stated that the claim "Claims 43-49 provide method claims for using a 3-D point cloud as described above, and each of these claims should be allowable for one or more of the reasons as described above." (Ex. G, Jan 31, 2011 Office Action Resp. at 22.) There is nothing in Claim 25 about "using a 3-D point cloud." Rather, a person of ordinary skill in the art would understand Claim 25 to relate to some type of safety or power saving feature.

143. As with the other processor claims, how the threshold level is determined is not disclosed. There is could be a broad array of methods used for safety or power saving reasons to set a threshold. Also, as previously explained, it might be necessary to continually adjust the threshold and it would not be understood by a person of ordinary skill in the art if adaptable thresholds would infringe upon the '558 Patent.

144. Finally, the specification and prosecution history do not inform those of ordinary skill in the art about the scope of the claim as to measuring the rotation of the "rotary component." (which Velodyne states is the motor). As explained previously, there is no disclosure in the specification of how to measure the rotation rate of the motor, and the only disclosure is of measuring the rotation of a housing. The disclosed device is a rotary rate measurement device, while it is described as a rotary position device.

145. For these reasons, this claim term, viewed in light of the specification and file history, does not sufficiently inform those skilled in the art about the scope of the invention with reasonable certainty.

2. As a Means-Plus-Function Term, the Term Does Not Disclose an Algorithm.

146. As I have previously described with respect to the Claim 16 term, the "processor" does not connote sufficiently definite structure. The same reasoning applies to Claim 25 and I incorporate my previous analysis here.

147. If Claim 25 is interpreted as a means-plus-function claim term, as described above, a person of ordinary skill would understand the specification to disclose a digital signal processor performing some algorithm as the disclosed structure. ('558 Patent, 5:11-12.) The specification does not disclose any algorithm for firing the emitters only when the rotary component is rotating above a certain threshold. As explained previously, there are numerous possible algorithms for determining the one or more thresholds that can be used depending on the required standard, and the particular "unique" circumstances of the structure. Some of these would result in infringement, while others would not. In the prosecution history, Velodyne states that unique requirements are needed for its claimed structure, but fails to provide any information regarding how those requirements are calculated or determined. For the many reasons described above, a person of skill in the art would not understand the specification to disclose any algorithm for performing the claimed function.

I. "A lidar-based 3-D point cloud system comprising" / "A method of generating a 3-D point cloud comprising"

148. The claims of the '558 Patent include these terms as their preambles. I understand that Velodyne has argued that the preamble is limiting. In my opinion, a person of skill in the art in scanning sensors would not find the preambles limiting, as they merely recite a possible application of the structures and methods disclosed in the claims.

149. Claim 1 of the '558 Patent recites the preamble "A lidar-based 3-D point cloud system comprising." ('558 Patent, Claim 1.) Claims 2 through 18 depend from Claim 1.

150. Claim 19 of the '558 Patent recites the preamble "A method of generating a 3-D point cloud comprising." ('558 Patent, Claim 19.) Claims 20 through 25 depend from Claim 19.

151. I understand that there are three situations when a preamble will limit a claim: (1) the preamble "recites essential structure or steps"; (2) the preamble is necessary to give "life,

meaning, and vitality" to the claim; or (3) there is a "clear reliance" on the preamble during prosecution to distinguish the claimed invention from prior art. The first two situations do *not* apply if the claim describes a "structurally complete invention," so that deleting the preamble would not affect the claimed invention's structure (i.e. the preamble is not essential to understanding the limitations or definition of terms in the claim body). When the claim describes a "structurally complete invention," the preamble is generally not limiting, and will only limit the claim if the third scenario applies.

152. Here, the preambles do not "recite essential structure or steps" and are not "necessary to give life, meaning and vitality to the claim. Rather, the claim limitations without the preambles describe a structurally complete invention.

153. For example, claim 1 recites:

> A lidar-based 3-D point cloud system comprising:
>
> a support structure;
>
> a plurality of laser emitters supported by the support structure;
>
> a plurality of avalanche photodiode detectors supported by the support structure; and
>
> a rotary component configured to rotate the plurality of laser emitters and the plurality of avalanche photodiode detectors at a speed of at least 200 RPM.

154. The preamble to claim 1 does not recite any essential structure to what is claimed in Claim 1 or its dependent claims. The claims dependent on claim 1 add additional structure, but a person of ordinary skill would not look back to the preamble of claim 1 to provide any structure to those claims. The structures in these claims stand on their own and form structurally complete inventions. In fact, the preamble of claim does not provide any structure, merely providing a description of a potential application of the claimed structure. Moreover, neither claim 1 nor any of its dependent claims rely on the preamble to provide antecedent basis for any limitation. Thus, a person of ordinary skill would have no reliance on the preamble to determine what structure infringes.

155. The preamble to Claim 19 similarly does not recite any essential steps to Claim 19, or its dependent claims (claims 19-25). Claim 19, for example, recites:

> A method of generating a 3-D point cloud comprising:
>
> [1] providing a lidar system having:
>
> a support structure,
>
> a plurality of laser emitters supported by the support structure;
>
> a plurality of avalanche photodiode detectors supported by the support structure, and
>
> a rotary component configured to rotate the plurality of laser emitters and the plurality of avalanche photodiode detectors at a speed of at least 200 RPM;
>
> [2] rotating the plurality of laser emitters and the plurality of avalanche photodiode detectors at a speed of at least 200RPM; and
>
> [3] emitting light from the plurality of laser emitters.

156. The preamble does not provide any essential steps to the method recited in Claim 19 or its dependent claims. The claims dependent on claim 19 add additional steps, but a person of ordinary skill would not look back to the preamble of claim 19 to provide any essential step to those claims. The steps in these claims stand on their own and form structurally complete inventions. In fact, the preamble of claim 19 does not provide any steps, merely providing a description of a potential application of the claimed structure, i.e., generating a 3-D point cloud. Moreover, neither claim 19 nor any of its dependent claims rely on the preamble to provide antecedent basis for any limitation. Thus, a person of ordinary skill would have no reliance on the preamble to determine what the claimed method covers.

1. The File History of the '558 Patent Does Not Indicate That Velodyne Clearly Relied on the Preambles to Distinguish Over the Prior Art.

157. A person of ordinary skill would also understand the file history of the claims to indicates that the third situation for when a preamble may be limiting does not apply. That is, there was no "clear reliance" on the preamble during prosecution to distinguish the claimed invention from prior art. Rather, the file history shows that the Velodyne relied on the existence of

the structures in the claim limitations – multiple emitters and APDs and rotation of at least 200 RPM – to distinguish the claims from the prior art.

158. On October 3, 2008, Velodyne had claims pending that recited, "***A lidar-based 3-D point cloud system comprising***: … ." (Ex. M, Oct. 3, 2008 Preliminary Amendment, at 2.) Thus, claim 11 in the file history had the same preamble as the current claim 1: "A lidar-based 3-D point cloud system." Claims 12-21, 23, and 24 in the file history were system claims dependent on claim 1. (*Id.* at 2-4.)

159. Similarly, claim 22 in the file history claimed "A method of generating 3-D point cloud, the method comprising: … ." (*Id.* at 3-4.) This was the same as the preamble to the current claim 19.

160. On September 2, 2010, a patent examiner rejected all of the pending claims 11-24 based on U.S. Patent Publication 2003/0090646 ("Riegl") in view of U.S. Patent Number 6,636,300 ("Doemens"). (Ex. H, Sept. 2, 2010 Non-Final Rejection, at 2.)

161. On January 31, 2011, Velodyne filed a response. Velodyne cancelled all of its pending claims 11-24 and stated that "for the sake of clarity" it was presenting new claims 25-49. (Ex. G, Jan. 31, 2011 Response to Office Action, at 6-8 (cancelling claims), at 8-12 (adding new claims), and at 13 ("In this response, the applicant has canceled claims 11-24 for the sake of clarity and has presented new claims 25-49.") The patentee then distinguished the Doemens and Reigl references from the new claims. (*Id.* at 13-22.)

162. Throughout its response, Velodyne relies on two factors to distinguish its new claims from the prior art: (1) a plurality (two or more) of laser emitters and a plurality (two or more) avalanche photodiode detectors (APDs), and (2) a rotation rate of at least 200 RPM. As shown in my summary of the patentee's response below, nowhere in the response did the patentee rely on the preamble to distinguish the claims, or claim that the prior art was not capable of generating a 3-D point cloud. Thus a person of ordinary skill would not have understood there to be any "clear reliance" on the preamble.

163. First, in its response, Velodyne distinguished the Doemens as follows:

> In general terms, Doemens describes a mechanically fixed array of individually modulable light sources for generating beams for illuminating an object, a mechanically fixed solid state image converter comprising a plurality of solid state light receiving elements arranged in an array corresponding to said array of light sources, and a mechanically fixed optical system for guiding light beams emanating from said sources to said object and for guiding light beams reflected from said object to said receiving elements, the optical system guiding each light beam reflected from the object to a selected receiving element corresponding to the light source from which the beam emanated. Quite plainly, t**he Doemens system is fixed, with no teaching or suggestion that it would be useful for rotation. In addition, it does not teach particular illumination distances, array angular alignments, rotation speeds, power levels, and other aspects of the claimed inventions. As a system constructed from CMOS or CCD sensors such as are used in conventional cameras, it cannot accommodate power levels consistent with components of the claimed invention and cannot scan images over the ranges possible with the claimed invention.**

(Ex. G at 13-14 (emphasis added of the bases on which the patentee distinguished the Doemens reference).) Thus, the patentee distinguished Doemens on the basis that it was a fixed system and not useful for rotation; did not teach particular illumination distances, array angular alignments, rotation speeds, power levels, and other aspects of the claimed inventions; and cannot accommodate power levels consistent with components of the claimed invention.

164. Next, Velodyne distinguishes the Riegl reference based on criteria other than their ability or inability to generate a 3-D point cloud.

> The Riegl device is a mechanical pan and scan sensor, using a beam splitter and moving prism to acquire a limited panoramic image. **Nothing about the Riegl device even remotely suggests the capability of performing in accordance with the claimed invention**; indeed, as explained further below Riegl is woefully deficient. Riegl, as with Doemens, **does not employ an array of avalanche photodiode detectors (APDs)**, but rather uses an array of photo elements such as CCD or CMOS devices as with Doemens. Accordingly, **Riegl teaches the use of a single APD to receive a portion of the return signal from the beam splitter**, with the actual imagery being received by the CCD or CMOS elements. **Because Riegl uses a gimballing prism for its vertical nodding, it cannot possibly spin at a high rate as claimed because it would intro-**

> **duce wobble and produce extremely limited results. Any effort to use the single APD of Riegl in a high RPM setting as claimed would lead to the conclusion that it simply cannot be done effectively.** Ultimately it would require the teachings from Riegl to be scrapped altogether in search of a system that could actually work. Indeed, in actual practice that has been the result as those who have tried a Riegl-type device have turned away from it and toward the commercial embodiment of the claimed device because it represents a significant advancement over the prior art. …

(Ex. T at 14 (emphasis added some of the language distinguishing Riegl from the claims of the invention).) Thus Velodyne distinguished Riegl on the basis that it did not teach multiple APDs, but rather, just a single APD; and that Riegl could not spin at the high rate claimed. Velodyne did not attempt to distinguish Riegl on the basis that it could not generate a 3-D point cloud - indeed Riegl discloses a system that generates a 3-D Point cloud. At most, Velodyne appears to argue that Riegl could not generate a 3-D point cloud fast enough for autonomous navigation, but that is not required by the claims.

165. Next, Velodyne describe the claimed invention in the newly added claims 25-49 (now claims 1-25 at a high level. (*Id.* at 15.) Nowhere in this description does the patentee state that the system is limited to a lidar-based 3-D point cloud generating system. Instead, a person of ordinary skill would understand the description to mean that one application that is well suited for the invention is the generation of a 3-D point cloud for autonomous vehicle navigation. The patentee made this clear by describing the invention as being "ideally suited" this application and a "preferred version" of the claimed device. (*Id.* at 15 ("The disclosed invention is "***ideally suited*** for the autonomous navigation context." and "***In a preferred version***, the claimed device provides, in a single 3D sensor, all the point cloud data necessary to construct a full terrain map of the surrounding environment suitable for a computer to make navigational decisions.").) When used in the preferred version, the patentee explained that there are various requirements, such as full field of view around the vehicle, and a dense point cloud. (*Id.*) Velodyne states that the Doemens and Riegl systems are designed for stationary use, and thus could not meet the demands of an autonomous navigation system. (*Id.* at 15-16.) The patentee does not, however, state that the invention is limited to use in autonomous vehicle navigation applications which re-

quire these features, to a system which generates a 3-D point cloud, or to a method for generating a 3-D point cloud.

166. Velodyne's January 31, 2011, office action response then turns to a distinguishing its new claims from Riegl and Doemens, in a claim-by-claim discussion. (*Id.* at 16-22.)

167. Velodyne distinguishes claim 25 from Riegl and Doemens because "A key point of distinction is the 200 RPM rotation speed for the APD detectors and laser emitters." (*Id.* at 16.) Velodyne goes on to argue that there is no motivation to use Doemens in a rotating device, and no need to use Riegl with a fast rotation speed. (*Id.* at 16-17.) Velodyne further argues that is would not have been obvious to use a device such as Riegl with a rotation speed above 200 RPM. Velodyne also distinguishes Riegl and Doemens, arguing that neither discloses more than one APD. (*Id.* at 18.) Velodyne does not claim or argue that there is any requirement in its claims to generate a 3-D point cloud, not to mention one that can be used on a vehicle or for autonomous navigation.

168. Next, Velodyne argues that secondary considerations indicate that its claimed device was not obvious, stating that "The commercial embodiment of the claimed invention has also met with spectacular success. … ." (*Id.* at 19-21.) The two declarations submitted in support of those secondary considerations solely discuss the use of the invention in the autonomous vehicle context, without mentioning other applications. Furthermore, economic success is dependent upon many other factors which may take precedence over non-obviousness. Throughout these discussions, while Velodyne argues that the use and alleged success of an embodiment of the invention in the autonomous vehicle context and for 3-D point clouds makes it non-obvious, nowhere does Velodyne limit the invention to that particular application, or distinguish from the prior art based on the prior art's inability to generate any 3-D point cloud. Rather, a person of ordinary skill would understand that the novelty that Velodyne was arguing lay with its structural limitations (multiple emitters, multiple detectors, and fast rotation), which could be used in one application, to generate a dense 3-D point could. The scope of the claims is thus that combination of structures, regardless of the application for which it is used.

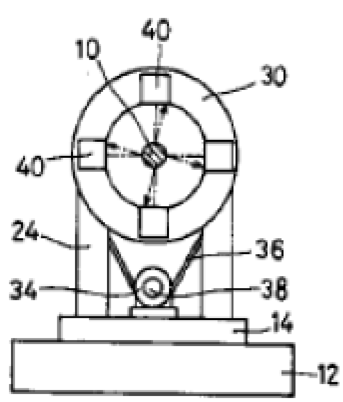
2. Holding the Preamble Limiting Would Narrow the Claim More Than Would Be Understood by a Person of Skill in the Art.

169. In my opinion, scanning sensors with the structures claimed in the '558 Patent are not limited to use to generate 3-D point clouds for avoiding obstacles or for automated vehicle navigation, and would not be understood as such by persons of ordinary skill in the art. For example, the structures claimed in the '558 Patent could just as easily be used to collect panoramic, 2D images at night or under conditions of otherwise limited visibility.

170. The dependent claims from Claim 1 recite the various specific features that Velodyne states would make the device suited to a particular application. Claims 6, 15, and 20 of the '558 patent, for example, require that the device is mounted on a vehicle, with claim 6 claiming how the angular separation should be provided in order to allow the sensor to reflect off of locations from 20 feet to 500 feet from the vehicle.

171. The applications of scanning sensors with multiple laser emitters, multiple detectors, and high speeds are useful in many contexts, and would be understood to be covered by the claims. For example, a person of ordinary skill in the art would understand the Mizuno prior art reference to disclose the use of four laser emitters/detector pairs (labeled as 40 in Figure 1 of Mizuno below), supported by a structure, and spinning at 3000-5000 RPM (Ex. N, Mizuno, at 4.).

Figure 1



(Ex. N, Mizuno, Figure 1.) The laser emitters emit light. (*See id.* at 2 ("Means for Resolving the Issues").) Mizuno discloses that this structure is used to determine the shape of an object passing through the center of the device. (*Id.* at 1 (Claims and "Industrial Field of Applicability") and 2-4 ("Operation and Effects of the Invention").) The object moving through can move very fast, such as several meters per second, and still have its full shape determined by the device. (*Id.* at 3 (move at high speed) and 5-6 (describing operation allowing precise shape measurement of device moving at high speed). A person of ordinary skill in the art would consider such a use of the structures disclosed by Claim 1 and the steps disclosed by Claim 19, to be covered by those claims.

172. As another example, the D'Ambrosia prior art reference discloses a "Scanning Intrusion Detection Device." (Ex. O at title.) The D'Ambrosia device, which is partially shown in Figure 2, below, includes multiple laser emitter/detector pairs, and spins. While D'Ambrosia only explicitly discloses a preferred embodiment wherein the device spins at 60 rpm, a person of ordinary skill in the art would understand the structural components and methods disclosed do not proscribe operation at higher rotation rates to include rates above 200 RPM or to otherwise be what is covered by the claims of the '558 Patent. The preambles do not inform or otherwise affect the understanding of a person of ordinary skill in the art as to what is covered by the claims.

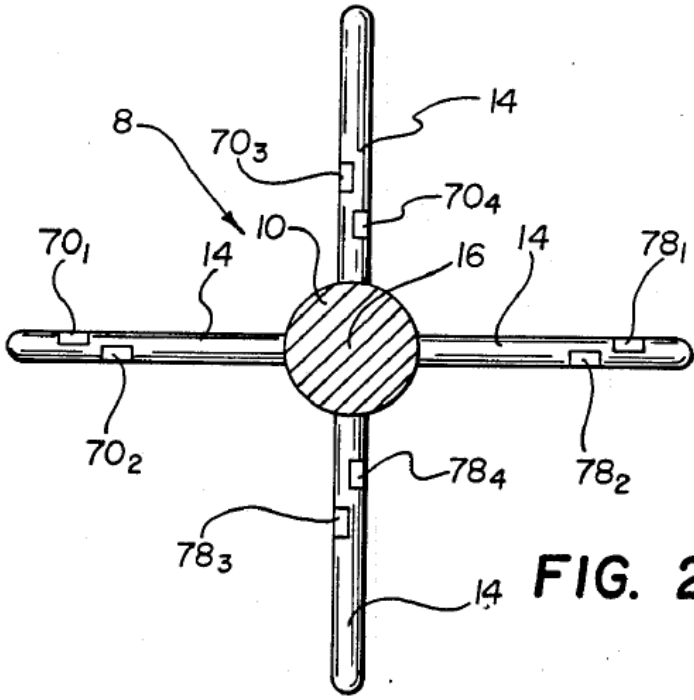
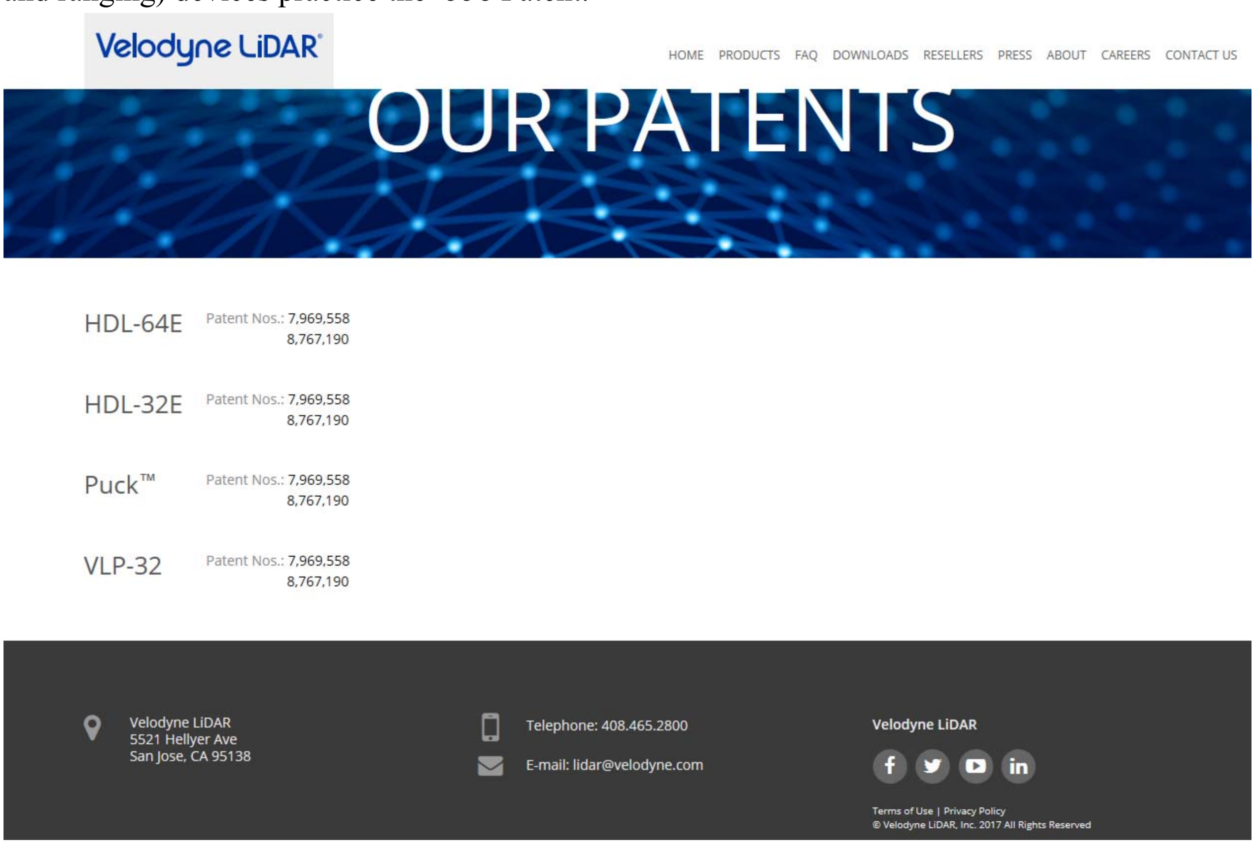


FIG. 2

173. Velodyne's own web site states that devices that practice the '558 Patent are used in many industries. According to Velodyne's web site, all of Velodyne's Lidar (light detection and ranging) devices practice the '558 Patent.



(Ex. P, http://velodynelidar.com/ip.) The HDL-63E, HDL-32E, Puck, and VLP-32 appear to be Velodyne lidar products. (Ex. Q, http://www.velodynelidar.com/products.html (which lists the HDL-64E, HDL-32E, and Puck products, and has a link to the "LiDAR Product Guide," which lists the VLP-16).).

174. Velodyne's web site states that its scanning products are applicable to a wide range of applications. (Ex. R, http://www.velodynelidar.com/industry.html.) This web site is entitled "Industry: Explore our key industries", and includes "Automotive, UAV, Industrial, and Mapping." The Industrial application section states that it can be used for "Object Profiling and Identification" as is performed by the device disclosed in the Mizuno prior art. Velodyne's own description of its products shows that the structures and methods of the '558 Patent are not claimed so as to be limited to specific applications or generation of 3-D point clouds.

J. "3-D point cloud"

175. I have been asked to provide an opinion as to the meaning of this claim term which is in the preambles of claims 1 and 20. As I explained in the previous section, the preambles are not limitations of the claims, so to a person of skill in the art, this term would not matter and would not need to be construed.

176. If it does require construction, in my opinion, the meaning of "3-D point cloud" to a person of ordinary skill in the art is "a collection of points in a 3-dimensional coordinate space."

177. This is the plain and ordinary meaning of "3-D point cloud" to a person of ordinary skill in the art. The term "3-D" stands for three-dimensional. A 3-D point is a point in a three dimensional coordinate space. Such points may be represented in a variety of coordinate systems. For example, one three-dimensional coordinate system is a Cartesian coordinate system, and would be represented by three, orthogonal distances (x, y, z) from an agreed location or origin. Another coordinate space is a spherical coordinate system wherein the 3-D point is represented by the radial distance from the origin, the polar or elevation angle, and the azimuthal angle (r, θ, φ) . A 3-D point can be represented in any three-dimensional coordinate space.

178. A 3-D point cloud is a collection of such 3-D points.

179. I understand that Velodyne's position is that a 3-D point cloud means "a collection of distance measurements along sequentially varied directions emitted and captured in rapid succession that can be rendered as a three-dimensional image or analyzed for other reasons such as detecting obstacles." I disagree with this proposed construction.

180. I understand that Velodyne relies on the following passage in the specification for this construction:

> ***When multiple pulses are emitted in rapid succession, and the direction of those emissions is somehow sequentially varied, each distance measurement can be considered a pixel, and a collection of pixels emitted and captured in rapid succession (called a "point cloud") can be rendered as an image or analyzed for other reasons such as detecting obstacles.*** Viewers that render these point clouds (today typically PC based) can manipulate the view to give the appearance of a 3-D image. While the data that comes back is lacking color or other characteristics, different schemes can be used to depict the distance measurements that allow the rendering device to show the 3-D image as if it were captured by a live action camera.

('558 Patent, 1:19-31.)

181. In my opinion, Velodyne's proposed construction is not supported by this paragraph and is not consistent with the plain and ordinary meaning of the term "3-D point cloud" which is used through the specification. It is also inaccurate and inconsistent with a large body of prior art.

182. First, 3D point clouds, which the paragraph above from the specification relates to, do not need to originate from laser pulses whether emitted in rapid succession or not. 3D point clouds can be created, for example, from conventional stereo pair photogrammetry, from synthetic aperture radar, from sonar, from structured light or other active optical parallax or from physical dimensional measurement.

183. Second, distance measurements are not "emitted and captured." It is the light pulses that are emitted, and the signal that result from reflection that are detected and measurements performed upon them that enable the determination of distance. A person of skill in the art would not understand the paragraph above as an intention by the patentee to define 3-D point

cloud, as such a definition would have taken care to use more precise terminology..

184. Third, a person of skill in the art would not understand this paragraph as attempting to limit 3-D point clouds to points collected by taking distance measurements "along sequentially varied directions." The specification describes that a 3-D point cloud can be generated without ever sequentially varying the direction in which the points are collected. For example, the specification describes that 3-D point clouds can be generated using Flash Lidar. ('558 Patent, 2:22-34.) As the specification describes, "flash" laser detection and ranging capture 3-D point clouds by simultaneously illuminating a large area, and capturing the resultant pixel-distance information on a specialized 2-D focal plane array (FPA)." (*Id.*, 2:22-25.) Flash lidar units thus capture 3-D point clouds by simultaneously illuminating a large area, not sequentially capturing the data over various directions. Velodyne's web site similarly describes flash lidar as a way of capturing 3-D point clouds without sequentially varying the direction in which points are collected.

> Flash LiDAR is a lower functionality alternative technology that illuminates a narrow field of view with one big flash while measuring the time it takes for the reflected light to return to a sensor array and calculate the individual distances. Flash LiDAR requires a much larger and more costly light source to illuminate the whole scene while only a fraction of the light that is reflected into the direction of the sensor is detected by the individual pixels … .

(Ex. S, http://velodynelidar.com/faq.html.) Both the plain and ordinary meaning and the descriptions of systems in the specifications that generate 3-D point clouds thus do not support requiring sequentially capturing the data over various directions.

185. Fourth, a person of ordinary skill in the art also would not understand the paragraph above to somehow be limiting point clouds to points that are generated from distance measurements "emitted and captured in rapid succession." For one, what constitutes "rapid" emission and capture of points in a point cloud is undefined. Construing "3-D point cloud" to require "rapid" light emission and capture would be contrary to the well understood meaning of the term to a person of ordinary skill in the art, including the use of the term in the '558 specification.

186. Moreover, the specification itself explains that 3-D point clouds can be collected slowly, stating:

> As noted above, ***3-D point cloud systems exist in several configurations***, the needs for autonomous vehicle navigation place unrealistic demands on current systems. For example, there are numerous systems that take excellent pictures, but ***take several minutes to collect a single image***. Such systems are unsuitable for highway use.

(*Id.*, 2:35-40.) This states that a 3-D point cloud can be collected, with sufficient information to form a single image, over several minutes. Whatever the meaning of "rapid" that Velodyne proposes to include in the definition of "3-D point cloud", one of ordinary skill in the art would think not that "rapid" means several minutes. But those too are "3-D point cloud systems." The laser sensors used on the Space Shuttle to detect and identify damage to the thermal protection tiles required many hours to collect the complete 3D point clouds of the exterior surface. I have personally generated point clouds using a lidar wherein the measurements we collected over many hours and even days. Because it is contrary to the ordinary meaning of the term "3-D point cloud" and contrary to the terms use in the specification, the term "3-D point cloud" would not be understood to require measurements "emitted and captured in rapid succession."

187. Fifth, a person of ordinary skill in the art also would not understand the paragraph above from the specification as attempting to limit "3-D point clouds" to those having to be used for any particular reason, such as the limitation Velodyne proposes, that it "can be rendered as a three-dimensional image or analyzed for other reasons such as detecting obstacles." The statement in the specification merely states that "point clouds" can be rendered as an image or analyzed for other reasons such as detecting obstacles. The statement says nothing about "three-dimensional images."

188. Moreover, the specification itself states that existing 3-D point cloud systems are not always suitable for certain purposes, such as "detecting obstacles." (*Id.*, 2:42-45 (stating that "[t]here are single beam systems that can create 3-D point clouds "but do not work well with objects that are small and fall outside the unit's field of view").) I agree that some single beam light detection and ranging sensors can generate 3-D point clouds that will not detect small objects. I am, however, also familiar with a single beam lidar sensor that was demonstrated to have

measured items as small as the contour of the retina of the eye. The detection of objects, or generation of an image is not a limitation of single beam systems. Furthermore, all sensors, including the invention disclosed in the '558 Patent cannot detect objects outside of their field of view. Thus, while some 3-D point clouds are used for certain applications, others are not. I know from my experience that there are 3-D point cloud systems that are not suitable for rendering images or for detecting obstacles in some circumstances. Thus, use in applications is neither a limitation of 3D point clouds nor a useful definition of the term.

189. The portion of the specification from which Velodyne claims to be taking its definition of 3-D point cloud, does not change its plain and ordinary meaning or change that it is used consistently in the specification to mean its plain and ordinary meaning.

Sixth, the amplitude of the signal that "comes back" is a characteristic that contains significant information concerning the reflectivity of the scene. The '558 Patent actual identifies that this characteristic is to be used for the purpose of safety. The scene reflectivity can be displayed and interpreted by a human in much the same way that a black and white photograph may be interpreted. Furthermore, the shape of the received pulse is a measure of the depth (i.e., the variation in range of the object or portion of an object illuminated by the laser emitter). Changes in the wavelength of the reflected radiation as a result of the Doppler effect are an indication of the velocity along the line of sight of the object illuminated by the laser. In addition, the reflected signal actually contains many colors even though the transmitted signal may have contained only one. The reflected colors are the result of the Raman shift and are indications of the chemical composition of the object illuminated by the laser emitter and its surface temperature. While I can find no indications within the '558 Patent that the invention is capable of measuring these additional characteristics of the received signal, other than the amplitude, the statement that "the data that comes back is lacking color or other characteristics" is factually in error. 3D point clouds may, and frequently do, include addition attributes or characteristics derived from the receive signal or from other external information sources.

190. Finally, it appears that Velodyne is trying to read multiple unrelated features to the term "3-D point cloud" in order to read additional claim limitations into the claims that are

simply not claimed. To a person of ordinary skill in the art, the claims, in light of the specification and file history, do not require the rotating device to collect information at a certain pace. The claims also do not specify that the density of the point cloud must be sufficient to generate an image or detect an obstacle of a certain size, the standard that Velodyne proposes should have been included in the claim. Moreover, the embodiment in the specification does not create a dense point cloud in all situations. If the device is used in an application like autonomous vehicles, in which the device is moved through space, it may create a dense point cloud, because the translation through space results in a dense capture of data points. However, in other non-"translational" applications, i.e., those in which the device is not moved through space rapidly, there would not necessarily be a dense point cloud generated. As shown above, the devices that practice the '558 Patent need not be used in such "translational" applications. Thus, the claims would not be understood to require the creation of the type of point cloud that might be required to generate an image or to detect obstacles.

191. To one of ordinary skilled in the art, the claims in light of the specification and file history, are not limited to generation of 3-D point cloud for use in autonomous vehicle navigation. These limitations are not in the claims, and a person of ordinary skill in the art would not understand the term "3-D point cloud" in the preamble to mean that a long list of additional limitations should be read into the claim.

192. Instead, Velodyne has described 3-D point clouds as applying to a wide variety of applications, and has claimed a structure that could be used in a wide variety of applications. (See discussion above regarding disclosures of use of the structures in defect detection, intrusion detection, and industrial applications.

193. Accordingly, the specification of the'558 Patent supports my opinion that the term "3-D point cloud," if it needs to be construed, has its plain and ordinary meaning, "a collection of points in a three-dimensional coordinate space.

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